THESIS/REPORTS
STREEBIN, L.

ROCK CREEK WATER QUALITY STUDY

Lolo National Forest
Missoula Ranger District
Missoula, Montana

Deerlodge National Forest
Philipsburg Ranger District
Philipsburg, Montana

by

School of Civil Engineering and Environmental Science
The University of Oklahoma
Norman, Oklahoma

October, 1970

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FORREST SERVICE
Region 1, Missoula, Montana 59801

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REPLY TO: 2540 - Water Uses and Development March 3, 1971

SUBJECT: Report of Rock Creek Water Quality Study

TO: Director, Intermountain Forest & Range Experiment Station,
Attention: Otis L. Copeland Ogden, Utah

Enclosed for your information is a copy of the Rock Creek Water Quality Study report.

This study was carried out by the School of Civil Engineering and Environmental Science of the University of Oklahoma under a contract with the Lolo Forest. Forest Supervisor Jack Large requested us to send you a copy of the report.

John C. Crupper

JOHN C. CRUPPER
Chief of Air and Watershed Management Branch
Division of Soil, Air, and Water Management

Enclosure

cc. Lolo

ACKNOWLEDGMENTS

This study was conducted as a joint effort by the University of Oklahoma and the U. S. Forest Service. It is felt by personnel of the University of Oklahoma, who were involved in the study, that it was an especially beneficial undertaking for those students participating. It is hoped that the information provided to the Forest Service by the study will be a valuable aid in continuing their resources management programs.

Special thanks are due Mr. Jack Large, Lolo National Forest Supervisor and Mr. Bob Lancaster, Deerlodge National Forest Supervisor for their cooperation and assistance in the study. Also much thanks are due to all Forest Service personnel involved in the study, who in every case, went out of their way in offering and providing assistance to make the study successful.

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INTRODUCTION

The University of Oklahoma, School of Civil Engineering and Environmental Science, in conjunction with the Lolo and Deerlodge National Forests has completed a summer water quality study on the Rock Creek Watershed. The study was designed to provide students with an opportunity to obtain practical experience monitoring water quality parameters while accomplishing a useful purpose in contributing information helpful to the Forest Service in making environmental quality control management decisions.

The parameters measured during this study were selected for the purpose of providing baseline data and information useful to the Forest Service in establishing a fisheries habitat and water quality management program for Rock Creek. It was also felt that the data collected might reveal changes in water quality of Rock Creek and its tributaries resulting from land use activities presently occurring in the watershed.

GENERAL DESCRIPTION OF AREA AND LAND MANAGEMENT PRACTICES

Since the Forest Service was the primary source of information concerning the general description and land management practices in the Rock Creek watershed, it is difficult to improve upon what they have already published. To avoid being repetitious, a brochure, provided by the Forest Service, which contains a general description of the watershed and land management practices is contained in this report as Appendix IV.

It should be noted that the 1553 cattle, shown in Appendix IV, to be permitted on Forest Service land, does not include many cattle and sheep grazed on private lands that lie within the Rock Creek watershed. Neither does the 41,565 acres of grazing land shown include a sizable area of private land that is suitable for grazing.

Much of the bottom meadow land lying adjacent to Rock Creek and its tributaries is suitable for raising hay and is fertilized for this purpose. This bottom meadow land is also occupied by the majority of cattle in the drainage area during the more severe part of the winter season. This fact is significant because organic material will be concentrated in areas adjacent to the tributaries, then released to the streams during the spring thaw.

SIGNIFICANCE OF LAND USE ACTIVITIES IN ROCK CREEK DRAINAGE BASIN

Logging

Logging is the principal industrial activity in the Rock Creek drainage basin. Present activity is confined to the upland portion of the lower creek basin and to the various tributary forks in the upper basin. Evidence of past logging activities is found in the canyon area of the lower creek.

Logging adversely affects water quality principally in three ways: increased sediment production, higher water temperature, and organic waste production. Logging can also have an affect on peak stream flows. Through proper logging techniques these can be controlled or at least minimized.

Sediment production is recognized as the most serious hazard to game fish resulting from logging activities. The available data overwhelmingly show that sedimentation reduces the survival of salmonoid embryos. (1) This is caused primarily by the affect that it has on gravel permeability and dissolved oxygen levels in the intragravel water. Suspended sediment in the form of turbidity is thought to have an adverse effect on salmonoid reproduction, because spawning becomes so concentrated in available clearer water that nests are destroyed by other nest-building females.

Increases in bottom sediment tends to fill the apertures and spaces around gravel, rubble and other bottom irregularities reducing protective cover for young fish and decreasing bottom productivity for aquatic

algae and insects. Studies have shown that aquatic reproduction is reduced as bottom irregularities become smaller. A decrease in aquatic insect production will have an obvious effect on the production of fish which feed upon these insects.

Roads, skid trails, and other soil disturbances are the primary cause of sediment and its associated problems. Current knowledge indicates roads are greater sources of sediment in logging than is the clearcut or harvesting operation itself. (1) Roads and skid trails tend to concentrate run-off and increase erosion hazard.

Prediction of the effects of logging on peak stream-flows in a specific area is complicated by the complex relationship among infiltration capacity, compaction and retention capacity, transpiration, and precipitation, but limited data has shown that peak flows can be expected to increase following logging. Accompanying the increased peak flow, abnormal gravel shifting can be expected to occur. Gravel shifting occurring in a stream at critical stages of fish embryo development can be disastrous to fish production. At the other extreme, excess logging debris can clog portions of stream used for spawning forming check dams that reduce flow velocity, and prevent adequate interchange of intragravel and surface waters thereby reducing the oxygen supply to developing embryos. This can also result in the collection of silt on the stream bottom in these areas causing loss of food producing rubble.

Higher water temperatures result from overhead canopy removal adjacent to stream. Complete removal exposes the water to the full impact of solar radiation. The change in temperature may be most dramatic in small, heavily vegetated streams. Removal of vegetation

destroys the cool shade sheltering the streambed. Water temperatures dangerously high for game fish may result. All of this points to the value of always preserving the overhead canopy immediately adjacent to streams in the logged area. Precautions should be taken in the planning of shaded areas adjacent to streams to reduce the danger of trees being felled by wind to which they may become more exposed.

Slash and other debris from logging activities contribute to organic and nutrient pollution of streams when they find their way to water. Increases in total dissolved solids, nitrates, and phosphates are some of the changes that might be expected. It is difficult to predict whether this will be detrimental or helpful to fish production, since algae and other constituents of the food web are increased and much depends upon the present condition of the stream. It is reasonable to conclude though, that any change in a stream which presently has a high fish production would be undesirable if the results of the change cannot be predicted.

Many water quality disturbances caused by logging may be traced back to roads and their construction, type of cutting and yarding techniques. Much information on these practices is found in the recent FWPCA publication, Industrial Waste Guide on Logging Practices.(2)

Roads are recognized as the primary source of sediment in logged areas. To minimize sediment production, care should be exercised in the design and location of roads to prevent channeling water over long distances and at scour velocities. In general, in the Rock Creek drainage, grades should be kept below 4% in granitics, and below 10-12% on favorable grades and 6-8% on adverse grades in the Belt Series.

The prime concern in road locations is keeping roadbeds away from creeks and out of unstable soil conditions. Meadow areas should be protected by locating roads around, rather than through meadows.

Types of cutting have obvious effects on water quality. Current practice employs two basic types, selective-cutting and clear-cutting with many techniques employed for each. Obviously in all cases the most practical technique which will have least adverse affect on stream water quality should be chosen. Type of cutting practice and log-yarding technique are largely controlled by tree species, forest management goals, volume of timber, terrain, and topography. All of these aspects must be considered to choose the harvesting techniques that minimize water quality disturbances. In those cases where the harvesting technique to be used will not insure the maintenance of desired stream water quality, the difficult decision as to the ultimate management goals must be made.

Summer Home Development

The immediate impact of summer home development upon the Rock Creek water quality and environment can in many ways resemble that which could result from unmanaged logging activities. The development of property in the canyon area along Rock Creek is proceeding at a rapid pace. Whereas logging activities occur in the upland areas, summer home development activities and its associated road construction and land clearing activities occur in areas immediately adjacent to the creek. Sites near the immediate area of the creek are naturally the most attractive for home development, and alterations to the terrestrial environment in this area can have the greatest influence on stream water quality.

The influence road construction has on sediment production and peak flows has already been discussed relative to logging activities. Where vegetation is removed along banks of streams, higher water temperatures can be expected to result as in the case with logging activities. Organic and nutrient pollution of stream water can also result from slash and other debris produced by land clearing activities.

The disposal of sewage from home developments along Rock Creek poses additional problems. The natural drainage in most of the areas where summer home development is occurring is toward the creek, and it can be expected that improperly disposed sewage will eventually find its way into the creek. This would be reflected by increased concentrations of nitrogenous compounds, phosphates, total dissolved solids and bacterial counts in the creek water.

In the absence of a sewage collection system, the most feasible method of sewage disposal for summer homes in this area is subsurface disposal systems. The satisfactory operation of this type of system depends upon soil conditions, and proper design and construction. Regular inspections of operating units would be recommended to guarantee continued proper operation. The health department regulations for the counties included in the Rock Creek drainage area require permits for the construction or alteration of subsurface disposal systems. These regulations stipulate that the disposal field shall be no closer than 50 feet to any stream. These regulations should provide some protection to the creek, but it has been shown that nitrogenous compounds can, under certain conditions, travel for considerable distances underground. The release of these compounds to the stream would provide an additional source of nutrients for increased algal production.

Any stream regardless of its characteristics can stand only so much pollution. Increased population and the concentration of large numbers of people in given locations have caused severe pollution in many areas. It has been estimated that 25 per cent of the sediment load dumped into the lower Potamac River is from housing and road construction sites in the Washington, D. C., area.

Agriculture

Agriculture in the form of ranching and associated crop production is a major activity in the upper reaches of Rock Creek. Storm water runoff over grazing and hay lands and irrigation return flows represent a source of pollution in this area. The water pollution problem associated with animal wastes frequently is a drainage problem. Runoff from confinement areas and from land used for disposal of the wastes occurs during and following rainfall or snow melt.

Actual documentation of pollution caused by animal wastes is rare due to the variable nature of rainfall relationships. The effect of such pollution is apparent in the number of fish kills that have occurred.

The fish kills attributable to animal wastes in Kansas and in the nation are presented in Table 1. Most of the fish kills caused by animal wastes occurred in Kansas. This suggests a greater awareness by Kansas officials of the pollution caused by animal wastes and not that the problem is unique to Kansas.

TABLE 1

	Fish Killed (Thousands)		
	1964	1965	1966
Kansas	1,100	571	1,000
United States	1,156	617	---

Storm runoff and irrigation return flows can be expected to carry large amounts of nitrogen and phosphorus compounds, dissolved organic solids, chlorides and bacteria into receiving waters. Where cultivation is practiced, sediment may also be a problem.

Concerning bacterial pollution, animal production can set the stage for the potential spread of disease. Although documentation of water borne disease transmission from animal to man is rare, such transmission has been noted. Several young people swimming in the Ceder River, Iowa, were infected with leptospirosis while swimming downstream from an area where leptospirosis infected cattle had access to the river.

Coliform organisms are used as an index of waterborne disease hazard. The per capita coliform output for cows, hogs, sheep, and ducks range from 2.9 to 9.3 times that of man. Fecal coliform organisms are more indicative of pollution from humans and animals. As will be noted later in this report, both total coliform and fecal coliform counts in Rock Creek and its tributaries were found to be low during this study.

With regards to return of total solids, BOD, COD, phosphates, and nitrogen to streams from agricultural lands, it has been shown in studies that little is contributed by meadow lands as compared to agricultural practices where soil is tilled or disturbed from its natural state.(3)

Pollution caused by animal production facilities can be as detrimental to a receiving water body as wastes from any other industry. Production facilities and confinement feeding have been developed with little planning and concern for the nuisance and pollutional characteristics inherent in the facilities. Many of the most obvious cases of

pollution could have been prevented if the facilities were located in areas less susceptible to runoff and to accidental release of wastes directly to receiving streams. The economics of pollution and nuisance control in animal production is an important factor and may mean the difference between success and failure for the facility.

Certain types of pollution have been classified as "natural" or "background" pollution. "Natural" pollution can come from a number of sources such as runoff from urban, rural, and forest lands, natural chloride seeps, decaying vegetation such as leaves and crop residue, animals on pasture and grazing land. Such pollution is difficult to control because of its diverse nature, lack of controllable point sources, and inadequate knowledge concerning feasible collection and treatment techniques. Also it has been assumed that this type of pollution not only is uncontrollable but is of small significance compared to municipal and industrial wastewaters.

Recent developments in animal production techniques have altered the traditional concept of including pollution from animal wastes as "background" or uncontrollable pollution. About one-half of the wastes from livestock remain on pasture and uncultivated land. The wastes from the remainder accumulate in pens, feedlots, and loafing areas. Increased automation and efficiency of crop use are expected to increase the latter fraction.

Mining

Recent mining activity in the Rock Creek drainage basin has been minimal, and the effects of such are insignificant compared to that from other activities.

Briefly, the effects on Rock Creek that might be expected from mining activity would include sediment production, increased dissolved solids, and increased concentration of certain heavy metals.

The road construction and disturbance of the natural soil state accompanying mine development would be expected to have much the same effect on sediment and peak flows as similar operations connected with other activities already mentioned.

Copper, silver, and manganese tests were conducted during this study. No tests were conducted for the presence of mercury. Near the end of the summer it was revealed to personnel conducting the study that considerable quantities of mercury used in old gold refining operations can still be found in the general area which includes Rock Creek. On the basis of this information, it is felt that determinations should be made for the presence of mercury in Rock Creek.

WATER QUALITY CRITERIA

Montana Water Quality Criteria

Rock Creek has been placed under the classification "B-D_1", by the State of Montana Water Pollution Control Council.

The council states that the quality of these waters shall be maintained suitable for drinking, culinary, and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection, and any additional treatment necessary to remove naturally present impurities; bathing, swimming, and recreation; growth and propagation of salmoniod fishes, and associated aquatic life, waterfowl and furbearers; agricultural and industrial water supply. Therefore, "B-D_1", equals "B", "C", "D", "E", and "F".

Under the "B-D_1", classification the following criteria for Rock Creek is established:

> Bacterial---Organisms of the coliform group by the most probable number or equivalent membrane filter method, during any consecutive 30-day period, and using a representative number of samples shall average less than 1000/100ml where demonstrated to be the result of domestic sewage, with not more than 20 per cent of the samples exceeding this value.
>
> Dissolved Oxygen---Dissolved oxygen shall not be allowed below the minimum concentration of 7 mg/liter.
>
> pH---Induced variation within the range, 6.5 to 8.5 shall be less than 0.5 pH unit. Natural pH outside listed range shall be maintained without change Natural pH above 7.0 shall be maintained above 7.0.
>
> Turbidity---Naturally occurring turbidity shall not be increased by more than 5 JTU or of sufficient quantity to adversely affect established levels of treatment.

Temperature---The following are allowable changes in naturally occurring water temperature:

> In the range 32°F to 67°F: 2°F maximum increase.
> Above 67°F: 0.5°F maximum increase.
> In the range 55°F to 32°F: 2°F maximum decrease.
> Above 55°F: 2°F per hour maximum decrease.
> Provided that water temperature must be below 40°F during winter season, and above 44°F during the summer season.

Residues---No increase in naturally occurring concentration that would adversely affect the use indicated for class "A-open" water, or that would adversely affect established levels of treatment of class "B" waters is allowable.

Sediment or Settable Solids---No increase in naturally occurring concentrations that would adversely affect the use indicated for class "A-open" waters, or that would adversely affect established levels of treatment of class "B" waters is allowable.

Toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metal compounds---Concentrations of chemical constituents shall conform with the 1962 U.S. Public Health Service Drinking Water Standards after conventional treatment. Maximum allowable concentrations shall be less than acute or chronic problem levels as revealed by bio-assay or other appropriate methods. In no case shall the following be exceeded:

> One-tenth of the four-day, median tolerance limit for short residual materials and one-hundredth of the four-day, median tolerance limit for pesticides and organic materials exhibiting a residual life exceeding 30 days in water. (Exceptions for beneficial purposes may be authorized by the Montana Water Pollution Control Council and the Federal Water Quality Administration).

Radioactivity---Concentrations of radioactive substances shall conform with the 1962 U.S. Public Health Service Drinking Water Standards except where concentration factors or aquatic flora and fauna exceed the recommended reduction factors, then maximum permissable limits shall be reduced below active or chronic problem levels. (These limits shall include natural background.)

Aesthetic considerations not covered under other water quality criteria---No waste (including phenolic compounds, and visible oils) offensive to the senses of sight, touch, smell, or tastes, not attributable to natural causes, shall

> be allowed. No excess nutrients which cause nuisance aquatic growths. Taste and odor causing materials shall not exceed levels which cause tainting of the flesh of edible species. Real color shall not exceed five units above naturally occurring color.

The above was taken from the State of Montana Water Quality Criteria adopted by the Montana Water Pollution Control Council in October, 1967.

The controlling limits discussed in the above excerpts from the Montana Water Quality Criteria are in most cases those necessary for the growth and propagation of salmoniod fishes and associated aquatic life. A discussion of parameters affecting salmonoid fishes follows in the next section.

Water Quality Criteria for Trout

When discussing the affects of pollutants on fish it can be misleading to set limits on individual pollutants. Considering even the short term, immediate action of different pollutants, Wilhm and Dorris (1968) note that variation and interaction of temperature, solid and chemical content, pH and external environmental conditions produce unpredictable and unaccountable results on waterlife.(4) Various combinations of pollutants and their interactions with the environment may cause either synergetic or antagonistic effects (Wilber, 1969).(6)

The effect of an environmental change may influence fish life indirectly through disturbances in the food web. Common aquatic invertibrates are shared as food by salmon, trout, minnows and other aquatic life. Decrease of available food sources accents competition. A change in one part of the environment initiates numerous shifts in the entire community.

Running water goes through a process of natural purification. Complicating the task of setting limits on polluting agents is the fact

that each stream varies in its own unique capacity to handle pollution. Parameters that apply to one location do not necessarily apply in another location. Self purification depends upon a number of factors, such as temperature, D.O., nitrogen content, velocity, turbulence and season of the year. The physical factors, width and depth are also important. The density of the silt and organic load added to a stream can alter purification ability over a period of time.

Another factor which complicates the task of establishing limits on polluting agents is the fact that dosages of pollutants that do not actually kill aquatic life may still cause adverse effects. Health or reproductive ability may be impaired. Mitrovic, et. al., (1968) determined the influence of phenol at concentrations 20% that of the Lc_{50} (lethal concentration to give a 50% kill). The gills of the fish were permanently damaged and reproduction was severely inhibited.(5)

The effects of siltation on spawning grounds, and bottom dwelling food sources have already been discussed relative to logging activities. Trout can withstand heavy loads of silt for a number of weeks, but their food supply and spawning grounds are destroyed (Wilber, 1969).(6) A complete change in the fish life was observed in a silt-polluted area in the Powder River in Oregon. Trout and white fish were completely eliminated (Wilson, 1957, as quoted by Wilber, 1969).(7) Deposition of sediment on trout beds in Montana streams killed developing embryos (Wilber, 1969).(6)

Organic wastes and fertilizers introduced into streams by irrigation as well as by livestock and other farming operations have been shown to have actually increased biomass of fish in some cases. (McFadden, Cooper, and Adams, 1965).(8) Fisheries are often fertilized to increase biomass. Additions of low levels of nutrients could actually benefit

acquatic life. Here again though, the entire ecology should be considered. Brook trout require cold, pure, unpolluted water. Bulldozing, dam building, de-forestation or any other type of pollution can eliminate brook trout. The rainbow trout can withstand some pollution. The introduced German brown trout have been shown to withstand pollution and fishing pressure that eliminate other trout (Smith, 1970).(9)

Although trout share a common food source with several other fish, they also consume large numbers of surface insects that are not in the diet of other fish. Pesticide contamination in surface waters would adversely affect trout. DDT utilized for spruce budworm control in Montana caused a delayed mortality in trout. Accumulation of DDT in the tissues, acquired from ingested insects, killed the fish.

The dead trout were found to contain as little as 0.5 mg/kg of DDT in their tissue. Also, complete or nearly complete kill of aquatic insects occurred in some sections of streams (Welch and Spindler, 1964).(10) It should also be remembered that DDT added to the food of trout in nonlethal doses has been shown to decrease disease tolerance (Wilber, 1969).(6) The effects of pesticides on selected groups of indicator organisms has been catalogued by the Federal Water Quality Administration in Water Quality Criteria (1968).(11)

A study was made of the toxic limit toward yearling trout of the acidic, basic, and neutral fractions of road tar. The toxic limit was defined as the concentration resulting in a loss of fish equilibrium in 60 minutes at 12°C. Toxicity in relation to boiling point and solubility is presented in Table 2.

TABLE 2

TOXIC ROAD TAR CONCENTRATIONS

Tar Fraction	Point, °C	Limit, mg/l	Solubility mg/l	Effective Toxicity*
Tar acids	197-210	6.00	16,500.0	27.500
	240-270	3.00	4,125.0	13.800
	270-300	2.00	1,375.0	6.880
	300-325	1.50	825.0	5.500
Tar bases	205-235	7.50	1,274.0	1.700
	230-250	7.50	951.0	1.270
	275-305	3.00	438.0	1.460
	320-345	1.00	238.0	2.380
Neutral oils	200-240	3.75	35.0	0.935
	240-280	3.75	25.3	0.675
	290-344	3.75	14.1	0.376

*Effective toxicity is given as solubility x 10^{-2} divided by toxic limit.

McKee, Jack Edward and Harold W. Wolf (1963), Water Quality Standard, California; 282.

Water quality standards for various species of fish are listed in Table 3. The data presented is at best incomplete. Antagonistic, synergistic, and accumulative factors are not considered. Also, disturbances in the intricate food web that influence fish indirectly are not considered.

TABLE 3

TROUT WATER QUALITY CRITERIA STANDARDS

The data presented is specified for trout or cold water streams (trout and salmon streams) unless otherwise specified.

PARAMETER	DISCUSSION OF LIMITS AND EFFECTS ON TROUT OR IN COLD WATER STREAMS
BOD	Swift mountain stream can handle 50 mg/1 of 5-day BOD without appreciable depletion of dissolved oxygen. Mckee and Wolf, 1963 (12)
Dissolved Solids	Limiting concentrations of dissolved solids for fresh-water fish not definitely known. 95% of all U.S. inland waters supporting good fish-fauna reported to have dissolved solids concentrations under 400 mg/liter. McKee and Wolf, 1963(12)
Hardness	Hardness is not recommended as criteria in setting water quality requirements for aquatic life. This is because hardness can be caused by a number of different divalent, metallic cations, some of which are beneficial and some detrimental to aquatic life. FWQA - Water Quality Criteria (1968) (11)
Alkalinity	Best Waters for support of diversified aquatic life are generally thought to be those with pH between 7 and 8 and having a total alkalinity of 100 to 120 mg/1 or more. This alkalinity serves as a buffer to help prevent sudden changes in pH. McKee and Wolf, 1963 (12)
pH	pH has synergetic effects with many substances toxic to fish. The Aquatic Life Advisory Committee of the Ohio River Valley Water Sanitation Commission reported that direct lethal effects of pH are not produced with a range of 5 to 9.5, but from the standpoint of productivity it is best to maintain the pH in the range of about 6.5 to 8.2. Some reports show trout surviving at pH levels as low as 3.3 and as high as 10.7. McKee and Wolf, 1963 (12)

TABLE 3 (cont'd)

DO	The lethal effect of low concentrations of dissolved oxygen appears to be increased by the presence of toxic substances such as excessive dissolved carbon dioxide, ammonia cyanides, zinc, lead, copper, or cresols. Some studies show that for spawning grounds, DO should be $\geq$7 mg/liter, for optimum growth DO should be $\geq$ 6 mg/liter. In unpolluted streams, DO level may drop to 5 mg/l to 6 mg/liter for short periods with no damage. DO $\leq$ 4 mg/l is considered critical. McKee and Wolf 1963 (12). Water Quality Criteria, 1968 (11)
Chlorides	200 mg/liter can be harmful. Choloride level is more toxic in soft waters. 95% of the streams in the U.S. that support a good fish population have a chloride content of less than 170 mg/liter. McKee and Wolf, 1963 (12)
Turbidity	600 ppm considered harmful to most fish life. 200 ppm (wood fibers, kaolin, distomaceous earth) kills trout. Herbert and Richards, 1963 (13) 50 ppm (coal dust, wood fiber) is harmful to trout. Optimumly, turbidity should be less than 10 JTU for cold water streams. Water Quality Criteria, 1968 (11)
Suspended Solids	Tests have shown that 30 mg/l of Kaolin and diatomaceous earth has no adverse affect on rainbow trout, while at 270 mg/l more than half of the fish died in 2 to 12 weeks. No difference in effect was detected between kaolin and diatomaceous earth. It should be pointed out that this test measured direct effects only. Indirect effects such as those on spawning and food supply were not measured. McKee and Wolf. 1963 (12)
1. Foreign floating debris	None should be present. Water Quality Criteria, 1968 (11)
2. Sawdust	Leaching may release toxic substances. BOD exerted reduces D.O.

TABLE 3 (cont'd)

Free CO_2	95% of all streams in the U.S. that support good fish populations have concentrations of less than 5.0mg/l. The source of free carbon dioxide in water is seldom that from the air phase, for CO_2 is a product of aerobic or anaerobic decomposition of organic matter. McKee and Wolf, 1963 (12)
Temperature	The optimum water temperature for rainbow trout has been shown to be 13°C. The median tolerance limit for common brook trout has been shown to be 26.1°C. McKee and Wolf, 1963 (12)
Nitrogen	Ammonia can be toxic to fish, but the concentration at which it becomes toxic is directly related to pH. As an example of the amount of ammonia that may be toxic, o.6 mg/l ammonia has been shown to be lethal to rainbow trout in 100-200 minutes. 95% of waters in the U.S. supporting good fish life have less than 4.2 mg/l nitrates. 50 mg/l of sodium nitrite has been shown to be fatal to minnows in 14 days. The importance of nitrogen is its effect on plant life in streams, an effect which is difficult to predict. McKee and Wolf, 1963 (12)
Phosphates	Many exotic phosphate compounds may be toxic to fish in concentrations as low as 15 mg/liter, but fish can tolerate higher concentrations of the common phosphate compounds found in nature. As with nitrogen, phosphates serve as nutrients for plant growth in streams. The concentrations that may produce detrimental algal growths in streams depend a great deal on many environmental factors that vary from stream to stream. These concentrations are difficult to predict. 100µg/liter has been given as the recommended upper limit, but factors affecting this are so varied that setting a limit such as this can be misleading. McKee and Wolf, 1963 (12) Water Quality Criteria (FWQA), 1968 (11)

DISCUSSION OF SAMPLING STATIONS

The establishment of baseline data to determine trends in water quality as related to land use was a prime objective in the selection of all sampling stations on Rock Creek and its tributaries. It was also desired to determine if the present water quality of Rock Creek meets those standards set forth by the Montana Water Pollution Control Council, and to detect any conditions which might be detrimental to the intended uses of Rock Creek. In addition to these over all objectives, each individual sampling station was selected for additional specific reasons. These additional reasons for selection along with a brief description of each station follows:

1. Station 1 is located just below the private bridge to the Valley of the Moon Ranch in Section 13, R17W, T11N, and right beside a stream gaging station. The principle activities occurring along the creek between Station 1 and Station 2 are of a recreational nature with some ranching and irrigation being practiced. It was felt that any impact on the stream from these activities would be reflected in a change in water quality between Station 2 and Station 1.

2. Station 2 is located at the footbridge over Rock Creek in Section 2, R17W, T9N. Its main purpose in addition to establishing base line data and determining water quality, is to serve as a comparison for evaluation of the data collected at Station 1 and Station 3.

3. Station 3 is located at the boundary of Lolo and Deerlodge National Forest in Section 7, R16W, T7N. This is also the location of

a stream gaging station. This station's primary purpose is to fulfill the project's general overall objectives already mentioned, and to provide information to determine any changes in water quality between Stations 7 and 3 and Stations 3 and 2 which might be associated with land use in these general locations. The primary land use activities occurring between Stations 3 and 2 are recreational home use and development and associated road construction with logging taking place on some tributaries entering the main creek between these stations. Between Stations 7 and 3 a considerable amount of land along the creek is devoted to ranching with a considerable amount of irrigation being practiced along land immediately adjacent to the main creek and along small tributaries, especially Upper Willow Creek. Some earth quarry operations for the purpose of road improvement were noted in this section along and immediately adjacent to the creek during the course of the study.

4. Station 7 is located on the main Rock Creek below the junction of the West Fork and the Middle Fork of Rock Creek in Section 31, R15W, T6N. A stream gaging station is also situated at this location. As mentioned previously, this station was selected to provide a base upon which water quality changes between Stations 7 and 3 might be determined.

5. The Grizzly Creek Station is located on Grizzly Creek at the point where Ranch Creek Road crosses the creek in Section 31, R16W, T10N. There has been little, if any, recent significant activity along Grizzly Creek although at one time the general area was the site of extensive mining activity. At this late date it is impossible to gage the effects that this mining activity may have had on the stream, but the watershed

for Grizzly Creek is to be logged in the not to distant future. The data collected at this station will be valuable benchmarks for determining any changes that may take place in the stream as a result of logging practices.

6. Station 2A is located at the mouth of Welcome Creek just above its junction with Rock Creek. Its purpose was to obtain water quality information on a stream in its natural state which has been relatively unaltered by human activity.

7. Stations 4 and 5 were selected in an attempt to determine changes that might have occurred in stream quality as a result of past and present logging activities. Station 4 is located on Wyman Creek at the location of a permanent stream gaging station approximately 150 yards above its mouth. Station 5 is located on Alder Creek approximately 200 yards above its mouth and at the location of a permanent stream gaging station. Wyman Creek has had no logging activity while Alder Creek's drainage area has been and is presently being logged.

8. Stations 8 and 9 were selected to compare the water quality in a stream which is relatively undeveloped with that found in a stream which has seen considerable land use along its reach. Station 8 is located on West Fork in Section 36, R16W, T6N, behind the Forest Service Work Center in the same section. Station 9 is located on Ross Fork in Section 26, R16W, T5N. Both sampling stations are at the same locations as permanent stream gaging stations. Considerable logging has taken place along the tributaries to West Fork and the area immediately adjacent to the creek is the site of significant ranching activity. The area above Station 9 on Ross Fork has seen little activity or development.

9. Stations 10 and 13 were selected on the Middle Fork to determine the effect of activities between these two stations and above Station 10. Station 10 is located in Section 18, R15W, T4N, and Station 13 is located below Station 10 at the road bridge in Section 17, R15W, T5N. The area between Station 10 and 13 is used primarily for ranching.

10. Station 6 and 6A are located on Upper Willow Creek and were selected to determine the effect of activities above Station 6 and changes in water quality between Station 6 and 6A which may be attributed to land use activities. The primary activity along and adjacent to the creek is ranching. No logging has occurred in National Forest Land along this stream.

11. Station 11 is located on Meadow Creek in Section 2, R15W, T4N, just upstream from the Deerlodge National Forest boundary. There has been considerable logging activity along this stream and extensive use of the stream's watershed is made for cattle grazing.

12. Station 12 is located immediately below the East Fork Reservoir. The flow in this stream was low during the course of this study, because a large proportion of its flow is diverted out of the Rock Creek Watershed for irrigation purposes. The data collected at this station is to be used to determine the effects of present and future activities on the stream. The effect that the reservoir has on the stream; temperature, etc; can be determined by comparing samples collected above the reservoir and at Station 12.

Portions of the above information were provided by the Forest Service which selected sampling stations to yield information which will most accurately indicate trends in water quality and effects that land use activities may have had on the present water quality of the stream. A map of Rock Creek watershed shown on Appendix IV.

DISCUSSION OF PAIRED STATIONS

Two sets of stations were selected for the purpose of studying the effects of certain land use practices upon stream water quality. The streams for each set were selected on the basis of their similarity in size and the presense or absense of particular land use activities on each individual stream. Chemical, physical, and biological parameters were then measured on samples from each stream to detect any differences in water quality that might be attributable to land use activities.

The streams selected for this portion of the study were Alder Creek to be paired with Wyman Creek and West Fork to be paired with Ross Fork. A description of each follows:

Alder Creek. The sampling station located on Alder Creek is station 5. Station 5 has been described in the previous section of this report. Alder Creek drains an area of approximately 4,860 acres. Of this 4,860 acres, approximately 200 acres is non-forested land and 700 acres has been cut-over in logging operations. Approximately 27 miles of roads are located in the drainage area.

Wyman Creek. Station 4, which has previously been described is located on Wyman Creek. Approximately 6,350 acres, 400 of which are non-forested land, are located in the Wyman Creek drainage basin. There has been no logging or road construction activity in the Wyman Creek drainage area.

Ross Fork. Station 9 is located on Ross Fork. The Ross Fork drainage basin covers approximately 25,855 acres and has been relatively undisturbed by human activity. On the lower portion of Ross Fork are located a number of ranches, but these are all below Station 9 where samples were collected.

West Fork. Samples for West Fork were collected at Station 8. There are approximately 31,298 acres located in the West Fork Watershed. A considerable amount of logging has occurred here, but the number of acres involved was not available to the writers of this report. Considerable ranching activity is practiced in the drainage area of West Fork.

It should be noted that many factors that can affect water quality but are difficult to measure were present in varying degrees on the different streams used for the paired stations study. For example, the geology and vegetation in the watersheds involved were not all of the same type. It is obvious that differences in geology would affect chemical and physical parameters measured no matter what land-use activity had occurred in the given area.

Since so many intangibles can be involved in determining the quality of water released from different drainage basins, drawing reliable conclusions based on the relatively small amount of data that can be collected during one summer from only two sets of streams is extremely difficult if not impossible. In order to make reliable conclusions, it would be necessary to make a statistical study of parameters measured on a much larger number of streams, or have much more data available from the two streams which had been paired.

DISCUSSION OF RESULTS

With the exception of heavy metals, tannin and lignin, and turbidity, all tests conducted in this study were performed in accordance with procedures set forth in the 12th edition of Standard Methods for the Examination of Water and Wastewater. Turbidity tests were performed by Hach procedures using the Hach Direct Reading-Engineering Laboratory. Metals and tannin and lignin were analyzed using Hach Chemical reagents and a Bausch and Lomb Spectronic 20.

It should be pointed out that the data in this report cannot be interpreted in any way to show that the quality of water in Rock Creek is either being deteriorated or improved by present activities being conducted along it or its tributaries. There were no data on the past condition of the stream with regards to the parameters tested upon which the authors of this report could base such an interpretation. The value and primary purpose of this study is to provide that base line data necessary to detect any future deterioration that may occur in stream quality so corrective measures may be taken.

Alkalinity

The alkalinity determined on samples from all stations was found to be of the bicarbonate form. No carbonate or hydroxide alkalinity was found at any locations.

In general the alkalinities determined on Rock Creek and its tributaries were found to lie in ranges that provide above the minimum

essential buffering capacity for stream water, although determinations made on samples collected on Ross Fork, (Station 9), West Fork, (Station 8), and the upper end of Upper Willow Creek, (Station 6), showed alkalinities to run generally below 20 mg/liter at these points. This does not necessarily mean that these streams have suffered any harmful effects, but indicates only that they have a lower than optimum buffering capacity.(11) It is quite possible that the natural alkalinity in these streams is low and in fact the geology of the area would indicate this.

It should be pointed out that the alkalinity of Upper Willow Creek increases as it flows from Station 6 to 6A and this increase in alkalinity is accompanied by an increase in chemical oxygen demand. The increase in chemical oxygen demand would be expected, because of the agricultural activity occurring along the banks of the stream. The increase in alkalinity could be caused by the stream flowing through some isolated deposits of weak acid salts.

The geology of the Upper Willow Creek drainage area changes near the mouth in the general area of Station 6A, with some limestone being present. In addition to explaining the increase in alkalinity it would also explain the increase in total dissolved solids that was measured between Station 6 and 6A.

The alkalinities measured at Stations 11 and 12 (Meadow Creek and East Fork Creek below East Fork Reservoir) were significantly higher than those measured at any other sampling station. The most apparent explanation of this is the geology of the watersheds of these particular streams.

Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is a measure of the biologically degradable organic matter in water in terms of the oxygen required for stabilization as contrasted with chemical oxygen demand (COD) which measures the oxygen demand of resistant organics in addition to that measured by the BOD.

The purpose for analyzing the BOD at the sampling stations was to obtain a ratio between the BOD and the COD of the water. Hence, the BOD was only analyzed enough times to indicate a trend.

The BOD of Rock Creek water was below the statistical limits of reliability for the test, even using the creek water without dilution. Therefore, the BOD of the stream water was below 2 mg/liter, the lower statistical limit of detectable BOD, indicating good water quality.

Microbiological Examination

The tests carried out at stations 1, 2, 3, and 7 were to determine the relative numbers of micro-organisms in the water which would indicate the extent of bacterial contamination. A millipore filter apparatus and standard millipore procedure (Standard Methods)(14) were used in the analysis.

Tests for coliform, fecal coliform, total bacteria and streptococcus organisms were conducted with the respective media; m-endo broth, m-endo broth, brain heart infusion, and enterococcus confirmatory agar.

The results of the tests conducted suggest no significant pollution due to fecal contamination. The relative numbers present are representative of soil bacteria, and bacteria from decaying organic material. A more extensive examination of fecal coliform is, however, suggested.

Bottom Samples

A Surber sampler was used to collect bottom samples from the designated stations. The specific locations were arbitrarily selected to obtain a characteristic section representative of the stream bottom. The entire bottom sample was washed through a funnel into collecting bottles, brought back to the laboratory, identified, and characteristic organisms preserved in 75% alcohol. The results were reported in biomass collected (grams) per square foot bottom area, and by types of organisms found.

The distribution and nature of the organisms collected give an indication of clean water. Ephemeroptera, Trichoptera, and Plecoptera species were plentiful in the bottom samples collected. These organisms are sensitive to abnormal water quality variations and their abundance would indicate that no deterioration in water quality has occurred. These and other organisms serve as an in stream food source for aquatic life.

Chemical Oxygen Demand

Chemical oxygen demand (COD) is a measure of organic matter present in water, expressed as its oxygen equivalent. Unlike biochemical oxygen demand (BOD), COD also measures biologically resistant organics that are not measured by BOD. Hence, COD is a better measure of total organic matter in the water.

The methods used in this study for COD were taken from Standard Methods and can accurately measure COD down to 10 mg/1.(14) Values below 10 mg/1 are less accurate, and can only be used to indicate the order of magnitude of COD. However, values less than 10 mg/1 indicate an extremely low level of organic matter in the water, and are an

indication of good water quality. In the case of Rock Creek, the level of organic material in the water was so low that special precautions were taken to assure clean glassware, free of traces of organic matter. Samples from the main branch of Rock Creek (below Station 7) generally had COD values less than 20 mg/1, and in many cases less than 10 mg/1. Side drainages such as Grizzly, Welcome, Alder, and Wyman Creek were generally below 10 mg/1. Concentrations in the tributary forks (above Station 7) in the upper basin area were generally below 15 mg/1, and many times below 10 mg/1. Station 6A at the mouth of Upper Willow Creek was consistently high in COD with respect to Station 6 upstream, and the Rock Creek drainage in general. Between stations 6 and 6A, Upper Willow Creek flows through an area of agricultural use, including grazing and irrigation. The increase in COD may be attributed to the agricultural uses; however, from the results obtained from this study one can only conclude that this is an area (Upper Willow Creek drainage) in which land management is worthy of further study.

COD concentrations were higher after rainfall. This was attributed to organic debris in the runoff. In fact, the unusual amount of precipitation during the period of this study probably increased the organic load of the creek above normal levels for this time of year. In view of this, samples taken on the last sampling trip were probably as good an indicator of normal organic level as any taken during the course of the study because of the time lapse since a general rainfall in the basin.

Chlorides

Chlorides are one of the principle anions found in water. However, in the Rock Creek drainage, only traces of chlorides were found.

This is, of course, an indication of good water quality. Although chlorides impart a salty taste to water, concentrations must exceed 250 mg/liter to be detected by taste alone. Apparently chlorides are not native in the geologic and soil formations in this area.

Any increase in the level of chlorides is an indication of pollution. Commonly referred to as a persistent chemical, its removal is not accomplished through natural purification processes. As a result, chlorides concentrations tend to accumulate in waters until dilution occurs. An increase in chloride concentration between two points in a stream would indicate pollution. Human and animal excretions contain chlorides, hence, chlorides can be an indication of pollution by warm blooded animals.

In the case of a stream like Rock Creek with a high reaeration rate, persistent chemicals such as chlorides may be more valuable as an indicator of pollution than oxygen depletion, because depletion of oxygen would be masked by reaeration.

Conductivity and Total Dissolved Solids

Conductivity, or specific conductance, is a measure of the capacity of a water to pass an electric current. Conductivity is closely related to the total dissolved solids (TDS) concentration. TDS will be discussed here, but the same discussion may be applied to conductivity by changing the units of measure.

TDS in the Rock Creek drainage are all within tolerable limits. Conductivity and TDS are highest at stations 11 and 12. This was to be expected because of the higher alkalinity values at these stations and the difference in the geology of the general area with respect to the other tributary forks. Stations 11 and 12 had a TDS concentration

ranging from 110 mg/l up to 153 mg/l. Station 12 was usually the lower of the two. TDS at the other stations rarely exceeded 100 mg/l and were as low as 19 mg/l at station 9. Stations 8 and 9 were consistently low and about the same.

Increases in total dissolved solids were consistently measured between stations 6 and 6A and also between stations 7 and 3. These increases were accompanied by increases in alkalinity. It is felt that these increases are a result of the geology of the area around the mouth of the Upper Willow Creek, where it empties into Rock Creek, although not enough information is available to definitely isolate the cause.

Decreases in total dissolved solids between stations 3 and 2 and stations 2 and 1 were due to dilution from side drainages. The stations located on tributaries entering the creek between stations 3 and 1 showed lower concentrations of TDS than were found in the main creek in this general location.

As would be expected, there is a relationship between increases in total dissolved solids and increases in alkalinity.

Dissolved Oxygen

Dissolved oxygen (DO) values obtained in the Rock Creek drainage were at or near saturation when corrected for elevation and temperature. High saturation values were attributed to aeration of the water by turbulence, lack of organic pollution, photosynthesis, and to a much lesser extent, diffusion at the air water interface. Little organic matter was available to deplete the high dissolved oxygen concentrations. Biodegradable pollutants would be indicated by a DO depletion.

All DO values were within the optimum range for trout. A large portion of the dissolved oxygen concentrations were found to be above

100 per cent saturation. The two principal causes of supersaturation occurring are photosynthetic production of oxygen by algae and water temperature variations. The variations in the water temperature could be caused by either diurnal changes or by the effect of changes in atmosphere temperature as the water flows from higher to lower elevations.

Since DO is such a critical parameter influencing the propagation of trout, sampling should be continued on a regular basis. To obtain additional information concerning the variations in degree of saturation, it would be advisable to run diurnal dissolved oxygen. This would provide information needed to better determine whether supersaturation is caused by temperature or photosynthesis effects.

Hardness (EDTA)

Hardness in water is caused by divalent metallic cations, principally calcium and magnesium. Strontium, iron, and aluminum may also contribute to hardness, but in such small relative concentrations as to be insignificant.

Total hardness (sum of calcium and magnesium hardness) was found to correlate closely with alkalinity, as would be expected. Hardness was approximately equal to the alkalinity, indicating primarily carbonate hardness in the water.

The hardness of natural waters is caused largely by contact with soil and rock formations. Generally, soft waters originate from areas of thin topsoil with little or no limestone.(15)

Softer waters would be expected from igneous drainage basins; while harder waters would be expected from sedimentary and meta-sedimentary drainage basins. This, at least in part, explains the greater hardness found at Stations 11 and 12, as contrasted with stations on the other

tributary forks. Limestone ($CaCO_3$) deposits located at the headwaters of East Fork and Meadow Creek probably contribute to the greater hardness at Stations 11 and 12. Water at Stations 11 and 12 may be classified as moderately hard (75 mg/l to 150 mg/l), while waters at all other stations may be classified as soft (less than 75 mg/l).

Hardness by itself has no biological significance and should be avoided when speaking of water quality requirements for aquatic life.(11) Some elements contributing to hardness may be beneficial to biological productivity, while others are toxic.

Hardness was analyzed in this study to provide base-line water quality data only. In the future, sampling for hardness four times annually should be sufficient if additional base-line data is desired. Two of the samples should correspond to high and low flows.

Nitrogen

The compounds of nitrogen as well as of phosphates are of interest because of their importance to the biological productivity of streams.(16) All forms of nitrogen are important, because algae and most other aquatic plants are capable of utilizing any available nitrogen in a very short time providing other growth conditions are favorable.(11) It is usually considered that nitrates supply nitrogen in more available form, although ammonia and nitrites are utilized.(17)

In this study, ammonia, nitrate, and nitrite nitrogen were determined. For use as base line data these are sufficient, since any increase in organic nitrogen, which was not determined, will be reflected by an increase in ammonia, nitrate, and nitrite nitrogen.

A major source of nitrogen compounds is drainage from agricultural areas.(16) This was borne out in this study by the results of ammonia

determinations. The ammonia concentrations were higher in those areas in which extensive agricultural activities were practiced. At those stations where water was derived from areas relatively free of activity, the ammonia concentrations were consistantly lowest.

Stations 6A, 7, 8, and 9 which were located on streams in areas of heavy agricultural use were consistantly higher in ammonia than were other stations. There was an increase in ammonia concentration as water flows from Station 6 to 6A on Upper Willow Creek. Between these two stations the stream flows through meadow land used extensively for agriculture. This increase in ammonia concentrations is consistant with the increase in chemical oxygen demand recorded between Stations 6 and 6A.

Alder Creek which has been exposed to some logging activity showed slightly lower levels of ammonia than Wyman Creek which has seen no recent logging activity. The ammonia levels in both of these streams were extremely low and fell considerably below those on streams in the areas of agricultural acitivity.

As expected no detectable concentrations of nitrite were found at any of the sampling stations.

Results from nitrate tests were variable and erratic, and no conclusions can be drawn as to the source of nitrogen compounds based upon nitrate data.

Phosphates

The allowable total phosphorus in a stream depends upon a variety of factors. It is not possible to determine the amount of phosphorus for optimum biological productivity in any particular stream based upon what has been found to be optimum for other streams. The nitrogen:

phosphorus ratio has been used as a parameter in establishing the optimum values, but even this will vary depending upon the water, season, temperature, and geological formations.

The phosphate levels in some of the tributaries of Rock Creek ranged from 0.10 to 0.19 mg/liter while those in Rock Creek Proper generally were below 0.1 mg/liter. These levels must necessarily be used as base line concentrations for these streams since there is no previously determined data available.

It is felt that the higher phosphate levels in the tributaries is caused by geological formations in the beds of these streams, although adequate geological information on these drainage areas could not be located. This assumption is backed up by the fact that most of the phosphates found in the tributaries were orthophophates. A larger proportion of phosphates resulting from human activity would be expected to enter the main Rock Creek rather than the tributaries because of the more extensive agricultural activity in this area.

pH

Due to equipment malfunctions the initial pH data collected was in error. Data collected after corrections were made in equipment showed pH ranges to be within those conducive to salmonoid production. As might be expected, those stations with highest alkalinity concentrations also showed highest pH values.

Suspended Sediments

A simplifying assumption of complete mixing in the water was made for suspended sediment sampling. Hence, the results are only an indicator of the order of magnitude.

Suspended sediments were below 30 mg/l and seldom above 10 mg/l. Supply problems limited analysis of more samples.

It is recommended that an integrated sediment sampler be used in the future to obtain more exacting results. This combined with good flow measurements will afford information on sediment transport in the Rock Creek drainage basin.

Tannin and Lignin

Tannin, a plant constituent, enters water from vegetative degradation processes. Both tannin and lignin are hydroxylated aromatic compounds. Because of the nature of this test, it is not specific for tannin or lignin. However, the relative resistivity of lignin to decomposition would indicate that it should not present a leaching problem, and that positive results would indicate tannin as the constituent found in the water. At any rate, results may simply be reported as hydroxylated aromatic compounds.(14)

Since tannin would be expected to be naturally in the water from fallen leaves and vegetative debris, this analysis was made only to determine the presence of outstanding differences or contrasts between stations.

Sampling indicated station 6A to be highest at 1 mg/l with all the other stations at varying lower concentrations. Sampling was limited, and no specific conclusions may be drawn at this time.

Temperature

Water temperatures found in the Rock Creek drainage were within the maximum tolerable limits for fish life and reproduction. Some variations in temperature occurred, however. These were principally

in reaches of the stream that were open and exposed to direct solar radiation (e.g., main branch of Rock Creek), and well shaded tributaries (e.g., Alder and Wyman Creeks).

Generally speaking, the main branch of Rock Creek was warmer than its tributaries. Temperatures as low as 6° and 7°C. were recorded in tributary streams during June and early July.

Solar radiation is believed to be responsible for all higher temperatures on the main creek. Silt in suspension absorbs heat and irrigation waters are warmed upon exposure to sunshine.(16) Both of these factors contribute to some degree in the Rock Creek drainage.

Turbidity

Turbid waters are those containing suspended matter that interferes with the passage of light. Turbidity is caused by a wide variety of suspended matter, from colloidal to coarse dispersions, depending upon the turbulence.(15)

A level of natural turbidity is to be expected in any stream. In the main branch of Rock Creek turbidity results were erratic. This was because turbidity is influenced by local precipitation conditions more than other parameters are. Throughout the last five weeks of sampling, turbidity stabilized at or below 10 Jackson Turbidity Units (JTU) in nearly all samples.

Heavy Metals

Stations 1, 7, 11, and 13 were monitored for the heavy metals. Extensive analyses were hampered by available laboratory equipment and facilities. Hence, samples were only analyzed for copper, manganese and silver.

Copper and manganese concentrations were below 0.03 mg/1 and 0.05 mg/1 respectively. The highest silver concentration was found at Station 13. However, all four stations were in the same order of magnitude, with concentrations ranging from .013 mg/1 to .026 mg/1. No evidence was found to indicate that these metals were present in significant concentrations.

It is recommended that samples of stream water be analyzed for heavy metals at least twice annually, preferably corresponding with periods of high and low runoff. Two metals of prime concern are mercury and lead. Lead is of interest as background data because it is sometimes found in areas of silver deposits, and there has been some silver mining in the Rock Creek area. Mercury is of interest in Rock Creek because of its use in ore reduction processes in early mining operations in the area.

CONCLUSIONS

1. Tests results show that during the summer study period, the quality of water in Rock Creek and the tributaries included in this study was excellent and conforms to the Montana Water Quality Criteria. To conclude whether the quality of water in Rock Creek is better or worse than in previous years is beyond the scope of this report. However, baseline data provided by this report should be useful in determining any future changes that may occur in the quality of Rock Creek water.

2. The Smith-Satterthwaite sample t test, using a 5% level of significance was performed on data collected for 10 parameters measured at stations 4 and 5. The results of these tests are contained on page 85 of this report. Based on the tests results at the 5% significance level, no difference was detected in total phosphate, chemical oxygen demand, nitrate nitrogen and pH values measured at each station. But, again at the 5% significance level, differences were found to exist in total hardness, total dissolved solids, ammonia nitrogen, total alkalinity, and turbidity measured at each station. It is quite possible that the difference in ammonia nitrogen concentrations is due to the fact that at the low concentrations found the test is not very sensitive, and this could result in some significant test errors.

No conclusion can be drawn as to whether the differences noted above are due to the presence or absence of certain activities in the particular drainage basins in question. To draw any such conclusions,

additional information and study would be necessary. For example, the natural geology of the two basins may be different leading to higher concentrations of alkalinity, hardness, and total dissolved solids being found in one stream than in the other. In the case of timber cutting activities, many of the effects that might be expected, would depend upon the proximity of the timber cut to the particular stream, the size and age of the cut, and the time at which samples are collected relative to rain storms.

3. As in the case of stations 4 and 5, the Smith-Satterthwaite sample t test was used to compare the data collected at stations 8 and 9. The results of these tests are contained on page 86 of this report. At the 5% significance level, no differences were detected at station 8 for total phosphate, total hardness, total dissolved solids, chemical oxygen demand, nitrate nitrogen, ammonia nitrogen, total alkalinity, or turbidity when compared with the same tests on samples from station 9. Based on this data, it can be concluded that during the period of study, no significant differences in quality, based upon parameters measured, were found to exist between the two streams. It cannot be concluded from this information that the activities occurring along the streams are not affecting the quality of water in the streams. As is the case with stations 4 and 5, additional study and information would be necessary to draw any such conclusions.

4. It is interesting to note that when the water quality at stations 4 and 5 are compared to each other, differences in the quality of water at the two stations are less apparent than when the quality of water at stations 4 and 5 are compared to the water quality at all other stations sampled. This is also true of stations 8 and 9. This would

seem to suggest that certain natural conditions or activities other than those for which the stations were paired to measure are primarily responsible for the differences noted in water quality between the different stations.

5. Tests data indicate that higher concentrations of most chemical and physical parameters are found in water at station 6A than are found in water at station 6. It is not conclusive whether these differences may be attributed to land use, to geologic origin, or to natural vegetation occurring next to the creek.

6. Although no statistical test was run on the data collected at stations 1 and 2, it is obvious from comparison of the means of measurement taken, that very little difference exists in the quality of water, as measured by our study, between the two stations.

RECOMMENDATIONS

1. Correlations between stream flows and stages recorded at sampling stations should be made and incorporated into the water quality measurements made during this study. A table listing the time that samples were collected is included in this report. Referencing water qaulity data to water flow at the time of sampling will make the task of comparing future water quality and detecting changes much simpler.

2. All tests run in the summer, 1970, study should be run in the summer, 1971, but on a 2 week basis. In addition to the tests conducted in 1970, organic nitrogen, and tannin and lignin determinations should be made. An integrated sediment sampling program should also be conducted.

Running samples every other week would allow time for using the Serco Sampler for collecting samples from selected locations after rainstorms.

3. Twice per year, samples should be taken from all stations for complete analyses, including heavy metals. These samples should be collected during the spring thaw when the creek is nearing peak flow period and during the yearly low flow period.

4. Samples should be collected from all stations in the watershed on a monthly basis and the following determinations should be made: Temperature, Dissolved Oxygen, pH, Total Dissolved Solids, Turbidity, *Nitrates, *Phosphates, *COD. Samples for those tests marked by asterisks should be preserved for transport to a laboratory with capabilities for conducting the specified tests.

Samples should be collected monthly and as near to the same day of the month as possible. During extreme winter weather, the above sampling schedule should be followed, except that snowbound stations other than 1, 3, 7, 8, 9 can be deleted.

5. The study of the paired stations should be continued. Additional information on the short term measurable effects, the indications of which are either rapidly washed downstream, or settled to the stream bottom should be collected. This would include collecting samples to determine the effects of rainstorms, and collecting samples during the spring thaw to determine if effects are apparent at these times which may not show up at other times. Additional information on the geology, relative topography, and vegative cover of the two areas should be collected.

6. The study of Grizzly Creek watershed should be continued. If logging operations do commence in this watershed, the data collected during the summer, 1970, study should be used for comparison to detect any changes in stream water quality.

7. Diurnal dissolved oxygen concentrations should be taken at selected stations where test data showed a relatively high number of supersaturated DO concentrations. Diurnal DO concentrations would provide some insight into reasons for supersaturated values occurring.

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APPENDIX I

PRESERVATION AND STORAGE OF SAMPLES

APPENDIX I

PRESERVATION AND STORAGE OF SAMPLES

The following is a discussion of the various steps that should be taken to preserve samples where immediate analysis is not possible. None of the methods discussed is 100% satisfactory, and efforts should be made to conduct the analyses as soon as possible after the sample is collected.

Standard Methods sets the following maximum limits as reasonable for physical and chemical analysis:

Unpolluted waters	72 hours
Slightly polluted waters	48 hours
Polluted waters	12 hours

The times shown above are maximum limits when no steps toward preservation are taken. If samples are preserved by addition of acid or germicide or by refrigeration they may be allowed to stand for longer periods of time. Whenever a preservative is added, the type and amount should be clearly stated on the container.

A discussion by test follows:

Alkalinity: Alkalinity should be run in the field if possible, because changes can occur in the pH-alkalinity-carbon dioxide balance which may cause calcium carbonate to precipitate and cause a decrease in the values for calcium and for total hardness. Where it is not practical to run this test in the field, the samples may be stored in polyethylene or pyrex bottles for up to one day before the test is run without significantly affecting the test.

Biochemical Oxygen Demand: Preservatives must not be added to samples used in this test. The sample should be chilled to 3^{o}-4^{o}C and kept at this temperature until it is incubated. No specific recommendations can be offered as to the time the sample may be stored before testing, because so many variables are involved. It is largly a matter of judgement, but for water of the quality found in Rock Creek, no significant changes should be expected to occur during transportation to laboratory facilities if the sample is properly chilled and no delay occurs in shipment.

Carbon Dioxide: Even with careful collection technique, some loss of free carbon dioxide can be expected in the storage and transit of the sample. Consequently, the field determination of free carbon dioxide immediately at the point of sampling is advisable. Where a field determination is impractical, a bottle of sample filled to the top should be collected separately for laboratory examination. The bottle sample should be kept, until tested, at a temperature lower than that at which the water was collected and the laboratory should be located sufficiently close so that the sample may be delivered with the least amount of delay.

Chemical Oxygen Demand: Samples for determining COD by the dichromate method (used in summer study) should be preserved by adding sufficient H_2SO_4 to obtain a final acidity of pH 3. Preservation should be sufficient for shipment to a laboratory equipped for analysis.

Chlorides: No special preservative precautions are necessary.

Specific Conductance: No storage problem should be encountered here since it is assumed conductivity will be run on site, with a conductivity meter. Temperatures should be recorded with conductivity for conversion purposes.

Dissolved Oxygen: Dissolved Oxygen should be run on site either with a dissolved oxygen meter or by the azide modification of the iodometric method or other appropriate method. If the azide modification is used, preservation of samples for 4-8 hours is accomplished by adding 0.7 ml conc H_2SO_4 and 1 ml sodium azide solution ($ZgNaN_3$ in 100 ml distilled water) to the 300 ml DO bottle. It is strongly recommended that the test be run completely on site, and under no circumstances should the sample have to be transported over one half day's driving distance from the point of collection before testing.

Hardness: The discussion of preservation steps for alkalinity applies also to hardness.

pH: The discussion of preservation steps for alkalinity applies also to pH.

Nitrogen: Samples for nitrogen determination may be preserved by the addition of 0.8 ml conc H_2SO_4 to 1 liter of sample. This should maintain the nitrogen balance until the sample can be received by a laboratory with the capabilities for performing the tests. The amount of conc H_2SO_4 added should be indicated on the sample container.

Phosphate: With the relatively small amounts of suspended material found in the water in Rock Creek, there should be no problem collecting a relatively sediment free sample. If total phosphate (ortho plus poly) is to be determined, no special precautions need be taken. If polyphosphate and orthophosphate are to be determined separately, conversion to orthophosphate may be retarded or arrested by addition of 5 ml of chloroform to 1 liter of sample.

Suspended Sediment: Samples should be stored in resistant glass bottles or plastic bottles, so as to prevent contact between air and

the sample. This is accomplished by completely filling the sample bottle and leaving no air spaces.

Tannin and Lignin: No special storage precautions are noted in Standard Methods.

Heavy Metals: Samples may be preserved satisfactorily for shipment to a laboratory for analyses by acidifying with concentrated hydrochloric or nitric acid to a pH of approximately 3.5.

Bacteriological: Samples may be collected and immediately shipped to a laboratory for analysis without refrigeration, but the time in transit should be for only a limited period. It would not be wise to try to ship such samples outside the State of Montana for analysis. It is recommended that the laboratory handling the analysis be consulted for their routine handling procedure.

Summary

1. Tests for all dissolved gases should be run in the field or a laboratory that is in close proximity to collection points.

2. Samples for the following tests may be shipped in one container without special preservative precautions. One sample (approximately 2 gallons) will suffice for all the tests. There should be no delay between collection and shipment. Tannin and Lignin, Chlorides, Specific Conductance, Hardness, pH, Turbidity, Total Suspended Solids, Hardness, Alkalinity. It is felt that no significant changes will occur, with water quality of the type found in Rock Creek, while the samples are in transit to a well equipped laboratory for analyses.

3. Samples for COD should be preserved by adding enough H_2SO_4 to obtain a final pH of 3. 100 ml of sample would be sufficient.

4. Samples for nitrogen should be preserved by adding 0.8ml conc. H_2SO_4 to one liter of sample. A one liter sample should be collected.

5. If only total phosphate is to be determined, sufficient sample for this may be taken from the two gallons specified in section 2 above. Total phosphate analysis should be sufficient for the Rock Creek study, but if orthophosphate and polyphosphate is desired a separate sample should be provided. In this case 5 ml of coloform should be added to a 1 liter sample.

6. Samples for heavy metals should be preserved by addition of enough concentrated hydrochloric acid or nitric acid to give a final pH of 3.5. One gallon of sample should be provided.

7. Samples for biochemical oxygen demand should be immediately chilled to 3^{o}-4^{o}C and shipped in this condition. For tests of water from Rock Creek, a 1 liter sample should be provided.

APPENDIX II

HACH DR-EL FOR TESTING WATER QUALITY ON ROCK CREEK

APPENDIX II

HACH, DR-EL FOR TESTING WATER QUALITY ON ROCK CREEK

Preferably, chemical and physical tests for water quality studies should be performed in accordance with Standard Methods for the Examination of Water and Wastewater, or in some cases more sophisticated procedures should be used. Where this is not practical, the Hach, Direct Reading-Portable Engineering Laboratory provides a relatively inexpensive means for monitoring certain water quality parameters on streams such as Rock Creek. Problems arise when using this kit for testing certain chemical parameters which are found in Rock Creek in such small concentrations as to be almost undetectable by Hach Kit procedures. A discussion of the applicability of the Hach Kit for measuring parameters monitored in the summer of 1970, follows:

Phenolphthalein and Total Alkalinity: The mean values of total alkalinity for the sampling stations monitored this summer showed a low concentration of 13.5 mg/liter and a high concentration of 105.1 mg/l. Readings of the titration burette provided with the Hach Kit can be estimated to the nearest 0.05 ml providing determinations to the nearest 5 mg/liter alkalinity. This precision should be satisfactory for detecting any significant changes in alkalinity, but by using a sample larger than the 10 ml called for in the instruction manual, the procedure could be made more sensitive. For example, using a 50 ml sample and the same titrating burette, alkalinity concentrations could be read to the nearest 2 mg/liter.

Carbon Dioxide: Only a few scattered measurements for carbon dioxide were made during the summer study. No detectable concentrations were measured in any of the tests conducted. The method for measuring carbon dioxide as outlined in the HachKit instruction manual will measure 40 mg/liter for each ml of titrant used. If a 1 ml pipet is used for titration, readings of the amount of titrant used can be made to the nearest 0.01 ml. This would measure carbon dioxide to 0.4 mg/liter, which should be sensitive enough to detect any increases in CO_2 concentration that may occur in the stream. If a pipet is used for titration, precautions should be taken to prevent the titrant from becoming contaminated with atmospheric carbon dioxide.

Chlorides: During the summer, chloride concentrations were found to be below 1 mg/liter. With the Hach procedures, 1 ml mecuric nitrate titrant equals 50 mg/liter. To measure a chloride concentration of 1 mg/liter, the titrant used must be measured to 1/50 ml. By using a sample volume larger than the 10 ml called for the sensitivity of the test may be increased, so that an increase in chloride concentration of only a few mg/liter can be detected.

Hardness: The calcium and total hardness methods outlined in the Hach Kit instruction manual can be made sensitive enough for use on Rock Creek by using a sample volume larger than the 10 ml which are called for in the instructions. The method here is the same as that explained for alkalinity.

Nitrate Nitrogen: The range of the means of nitrate nitrogen concentrations measured during the summer study were from 0.0 mg/liter to 0.08 mg/liter. The sensitivity of the Hach Kit procedures is not great enough for the test to be run with any degree of accuracy.

Nitrite Nitrogen: The nitrite nitrogen concentrations as measured by Standard Methods procedures were found to be non-detectable in nearly all cases. The Hach Kit procedures do not have the sensitivity to justify their use in running this test.

Ammonia Nitrogen: The mean values for ammonia nitrogen concentrations determined during the summer study ranged from 0.006 mg/liter to 0.194 mg/liter. Those Hach Kits that have ammonia nitrogen meter scale do not have sufficient sensitivity to justify conducting the test by these methods.

Dissolved Oxygen: The method for determined dissolved oxygen, listed in the Hach Kit instruction manual will probably be satisfactory for simple rough determinations of dissolved oxygen. It is felt that for accurate records to determine any long term changes, either a Standard Methods procedure or a dissolved oxygen meter calibrated against a Standard Methods procedure should be used.

pH: It was found during the summer study that a heavy duty, portable pH meter of high quality cannot be satisfactorily replaced by any other method of determining pH.

Total Phosphate: The mean values of total phosphate concentrations were found to range from 0.64 mg/liter to 0.170 mg/liter during the summer, 1970, study period. These values lie so low in the range detectable by the Hach Kit as to make it advisable not to use this method of analysis.

Turbidity Measurements: The precision of turbidity measurements in the low range of turbidity found in Rock Creek water left something to be desired. Slight differences in reading were at times noted for the same sample. For the purpose of compiling and maintaining permanent

records of turbidity, it is advisable that the Hach DR-EL not be used.

Heavy Metals: Concentrations of heavy metals in Rock Creek are so low as to prohibit their accurate determination by ordinary methods available in field laboratories or portable units. Samples collected for the purpose of determining heavy metals concentration should be sent to well equipped labs where the more sensitive equipment such as atomic absorption spectrophotometry instruments are available.

APPENDIX III

DATA TABULATION

TABLE 4

TOTAL ALKALINITY (Mg/Liter)

Station Number

DATE	1	2	2A	3	4	5	6	6A
22 June	40	42	38	40	38	38	--	--
25 June	42	42	28	46	30	30	12	30
29 June	42	46	26	48	24	36	--	30
2 July	42	42	24	46	34	32	14	26
6 July	42	42	42	48	26	34	16	32
8 July	54	54	26	60	28	36	--	30
13 July	52	52	28	64	24	38	14	22
21 July	58	62	32	72	42	32	18	28
27 July	56	66	34	74	30	48	--	--
28 July	--	--	--	--	--	--	18	26
3 Aug.	64	64	36	76	--	--	20	30
10 Aug.	60	62	38	72	28	44	12	28

Station Number

DATE	7	8	9	10	11	12	13	Griz
22 June	28	10	12	36	94	86	--	38
25 June	30	10	12	--	--	--	26	40
29 June	34	12	10	--	--	--	34	40
2 July	24	10	10	34	82	90	36	36
6 July	36	14	18	40	96	88	48	50
8 July	44	14	16	--	--	--	44	44
13 July	38	12	16	44	108	88	34	69
21 July	48	16	26	50	116	86	50	52
27 July	--	--	--	--	--	--	--	64
28 July	42	18	20	52	116	104	58	--
3 Aug.	46	18	--	--	--	--	--	58
10 Aug.	50	14	24	56	124	116	58	58

TABLE 5

COD (Mg/liter)

*This day's samples are of doubtful value because of an error in the blank and are not considered in calculation of statistics.

Station Number

DATE	1	2	2A	3	4	5	6	6A
22 June	11.9	5.4	ND	1.1	1.1	ND	--	--
23 June	--	--	--	--	--	--	--	--
25 June	7.6	10.7	5.0	6.1	8.8	9.9	14.9	26.7
29 June*	15.6	22.4	14.2	23.1	38.0	19.7	--	61.2
1 July	20.4	18.4	2.7	4.8	14.2	4.1	31.3	16.3
6 July	6.8	10.2	ND	12.9	6.1	6.1	6.1	21.1
8 July	4.4	3.9	ND	2.2	11.1	ND	--	17.2
13 July	1.7	7.0	7.0	--	--	--	--	--
14 July	--	--	--	11.0	12.2	15.7	4.1	16.2
20 July	--	--	--	--	--	--	7.4	9.5
21 July	4.2	2.6	ND	6.9	9.0	3.2	--	--
27 July	7.0	6.0	5.5	10.0	10.0	9.0	--	--
28 July	--	--	--	--	--	--	12.0	27.0
3 Aug.	4.6	5.5	1.8	5.5	--	--	5.5	8.2
10 Aug.	8.3	6.4	3.7	6.4	8.3	10.1	--	--
11 Aug.	--	--	--	--	--	--	4.6	4.6

Station Number

DATE	7	8	9	10	11	12	13	G
22 June	--	--	--	--	--	--	--	ND
23 June	15.1	15.1	21.2	12.1	9.0	15.1	--	--
25 June	13.4	12.6	10.7	--	--	--	6.9	ND
29 June*	42.8	46.2	51.0	--	--	--	38.0	25.8
1 July	8.8	27.9	12.9	7.5	5.4	3.4	3.4	2.0
6 July	13.6	12.2	19.0	2.7	9.5	ND	10.2	3.4
8 July	2.2	2.2	4.4	--	--	--	1.7	ND
13 July	--	--	--	--	--	--	--	2.3
14 July	9.9	9.9	12.8	ND	4.1	ND	ND	--
20 July	11.1	12.7	10.0	6.3	12.1	2.1	5.3	--
21 July	--	--	--	--	--	--	--	2.1
27 July	--	--	--	--	--	--	--	7.0
28 July	21.0	15.0	16.0	9.0	7.5	5.5	8.0	--
3 Aug.	6.4	8.2	--	--	--	--	--	8.2
10 Aug.	--	--	--	--	--	--	--	4.6
11 Aug.	11.0	11.0	7.4	5.5	5.5	4.6	3.7	--

Note: Called N.D. = 0.50 for statistical purposes.

TABLE 6

TOTAL HARDNESS (mg./liter as Ca CO3)

Station Number

DATE	1	2	2A	3	4	5	6	6A
22 June	37	38	36	42	30	35	--	--
23 June	--	--	--	--	--	--	--	--
24 June	42	43	26	46	28	38	12	30
29 June	46	48	27	52	26	37	--	34
1 July	45	46	27	51	25	35	13	28
6 July	51	48	27	54	24	35	21	31
8 July	54	54	30	64	25	37	--	33
13 July	54	58	32	--	--	--	--	--
14 July	--	--	--	66	25	38	17	27
20 July	--	--	--	--	--	--	18	22
21 July	65	65	35	75	43	28	--	--
27 July	71	78	39	73	34	29	--	--
28 July	--	--	--	--	--	--	21	29
3 Aug.	60	62	40	73	--	--	18	35
10 Aug.	60	65	33	74	25	42	--	--
11 Aug.	--	--	--	--	--	--	10	24

Station Number

DATE	7	8	9	10	11	12	13	G
22 June	--	--	--	--	--	--	--	22
23 June	23	12	10	36	99	92	--	--
25 June	30	8	11	--	--	--	36	41
29 June	37	18	10	--	--	--	35	45
1 July	30	15	19	38	92	101	39	40
6 July	36	11	20	44	101	89	44	42
8 July	42	17	17	--	--	--	46	50
13 July	--	--	--	--	--	--	--	47
14 July	40	13	12	46	115	99	42	--
20 July	45	16	24	53	125	93	50	--
21 July	--	--	--	--	--	--	--	56
27 July	--	--	--	--	--	--	--	63
28 July	57	26	32	63	126	112	63	--
3 Aug.	48	15	--	--	--	--	--	63
10 Aug.	--	--	--	--	--	--	--	58
11 Aug.	49	11	20	55	129	121	57	--

TABLE 7

AMMONIA (Mg./liter Ammonia Nitrogen)

Station Number

DATE	1	2	2A	3	4	5	6	6A
22 June	0.09	0.08	ND	0.09	0.08	ND	--	--
23 June	--	--	--	--	--	--	--	--
25 June	0.09	0.09	ND	0.07	0.04	0.10	0.02	0.28
29 June	0.02	ND	0.02	0.06	0.04	0.01	--	0.18
1 July	0.12	0.14	ND	0.08	0.09	ND	0.09	0.30
6 July	0.02	0.09	ND	0.06	0.08	0.02	0.04	0.25
8 July	0.06	0.09	ND	0.05	0.09	ND	--	0.34
13 July	0.02	0.02	ND	--	--	--	--	--
14 July	--	--	--	0.09	0.17	0.01	0.11	0.38
20 July	--	--	--	--	--	--	0.01	0.12
21 July	0.01	0.02	ND	0.02	0.05	0.01	--	--
27 July	0.05	0.07	0.03	0.08	0.07	0.03	--	--
28 July	--	--	--	--	--	--	0.15	0.24
3 Aug.	0.05	0.05	0.01	0.05	--	--	0.08	0.09
10 Aug.	0.07	0.02	0.01	0.06	0.09	0.02	--	--
11 Aug.	--	--	--	--	--	--	0.09	0.12

Station Number

DATE	7	8	9	10	11	12	13	G
22 June	--	--	--	--	--	--	--	ND
23 June	0.14	0.19	0.20	0.27	0.02	0.07	--	--
25 June	0.08	0.12	0.15	--	--	--	0.04	0.02
29 June	0.08	0.06	ND	--	--	--	ND	ND
1 July	0.11	0.47	0.25	ND	0.04	ND	0.03	ND
6 July	0.12	0.24	0.20	ND	0.06	ND	0.06	ND
8 July	0.11	0.17	0.21	--	--	--	0.03	ND
13 July	--	--	--	--	--	--	--	ND
14 July	0.13	0.24	0.30	ND	0.02	ND	0.04	--
20 July	0.06	0.07	0.12	0.02	ND	ND	ND	--
21 July	--	--	--	--	--	--	--	ND
27 July	--	--	--	--	--	--	--	0.02
28 July	0.12	0.17	0.15	0.07	0.06	0.02	0.05	--
3 Aug.	0.08	0.09	--	--	--	--	--	0.02
10 Aug.	--	--	--	--	--	--	--	0.07
11 Aug.	0.08	0.14	0.09	0.03	0.06	0.02	0.02	--

* Note: Called ND = 0.00 for statistical purposes.

TABLE 8

NITRATE (Mg./liter Nitrate Nitrogen)

Station Number

DATE	1	2	2A	3	4	5	6	6A
22 June	--	0.1	ND	ND	ND	ND	--	--
23 June	--	--	--	--	--	--	--	--
25 June	--	ND	ND	ND	--	ND	ND	--
29 June	0.1	0.1	0.1	0.1	0.1	0.1	--	0.1
1 July	0.2	ND	ND	--	ND	ND	0.1	0.2
6 July	0.1	0.4	0.2	0.6	0.4	0.4	0.2	0.3
8 July	ND	ND	ND	ND	ND	0.1	--	ND
13 July	ND	ND	ND	--	--	--	--	--
14 July	--	--	--	ND	ND	0.1	ND	ND
20 July	--	--	--	--	--	--	ND	ND
21 July	ND	ND	ND	ND	ND	ND	--	--
27 July	ND	ND	ND	ND	ND	ND	--	--
28 July	--	--	--	--	--	--	ND	ND
3 Aug.	ND	ND	ND	ND	--	--	ND	ND
10 Aug.	ND	ND	ND	ND	ND	ND	--	--
11 Aug.	--	--	--	--	--	--	ND	--

Station Number

DATE	7	8	9	10	11	12	13	G
22 June	--	--	--	--	--	--	--	0.1
23 June	ND	0.1	0.1	ND	ND	ND	--	--
25 June	ND	ND	--	--	--	--	--	--
29 June	0.1	0.2	0.1	--	--	--	0.1	0.1
1 July	0.1	ND	0.2	ND	ND	ND	ND	ND
6 July	0.3	0.3	0.2	--	o.2	0.3	0.3	0.5
8 July	ND	ND	ND	--	--	--	ND	0.1
13 July	--	--	--	--	--	--	--	ND
14 July	ND	ND	ND	ND	ND	0.1	ND	ND
20 July	ND	ND	ND	ND	ND	ND	ND	--
21 July	--	--	--	--	--	--	--	ND
27 July	--	--	--	--	--	--	--	ND
28 July	ND	ND	ND	ND	ND	ND	ND	--
3 Aug.	ND	ND	--	--	--	--	--	--
10 Aug.	--	--	--	--	--	--	--	ND
11 Aug.	ND	ND	ND	ND	ND	ND	ND	--

* Note: Called ND = 0.00 for statistical purposes.

TABLE 9

pH

Station Number

DATE	1	2	2A	3	4	5	6	6A
22 June	8.1	8.1	8.4	8.3	8.3	8.3	--	--
23 June	--	--	--	--	--	--	--	--
25 June	9.6	8.0	8.4	8.5	8.6	9.1	--	--
29 June	pH meter not in working condition----------							
1 July	pH meter not in working condition----------							
6 July	pH meter not in working condition----------							
8 July	8.1	--	7.9	8.2	7.8	8.0	--	7.8
13 July	7.5	7.8	7.5	--	--	--	--	--
14 July	--	--	--	7.6	7.5	7.7	7.4	7.6
20 July	--	--	--	--	--	--	7.4	7.8
21 July	7.9	8.3	7.8	8.2	7.9	7.7	--	--
27 July	8.1	8.3	7.9	8.3	7.9	8.0	--	--
28 July	--	--	--	--	--	--	7.6	7.4
3 Aug.	8.1	8.4	7.9	8.3	--	--	7.5	7.8
10 Aug.	8.1	8.4	7.9	8.2	7.9	7.9	--	--
11 Aug.	--	--	--	--	--	--	7.6	7.5

Station Number

DATE	7	8	9	10	11	12	13	G
22 June	--	--	--	--	--	--	--	8.2
23 June	8.5	8.4	8.8	8.3	9.0	9.1	--	--
25 June	--	--	--	--	--	--	--	7.5
29 June	pH meter not in working condition----------							
1 July	pH meter not in working condition----------							
6 July	pH meter not in working condition----------							
8 July	8.0	7.5	7.2	--	--	--	7.8	7.7
13 July	--	--	--	--	--	--	--	7.6
14 July	7.9	7.3	7.3	7.9	8.2	8.1	8.1	--
20 July	8.0	7.5	7.5	7.9	8.3	8.2	8.0	--
21 July	--	--	--	--	--	--	--	8.0
27 July	--	--	--	--	--	--	--	8.1
28 July	8.0	7.5	7.5	8.0	8.4	8.4	8.1	--
3 Aug.	8.0	7.5	--	--	--	--	--	8.0
10 Aug.	--	--	--	--	--	--	--	8.0
11 Aug.	8.0	7.6	7.6	8.1	8.2	8.4	8.2	--

TABLE 10

TOTAL PHOSPHATE (Mg./liter PO_4)

Station Number

DATE	1	2	2A	3	4	5	6	6A
22 June	0.07	0.12	0.16	0.06	0.07	0.11	--	--
23 June	--	--	--	--	--	--	--	--
25 June	0.09	0.09	0.19	0.07	0.08	0.61*	0.13	0.16
29 June	0.13	0.20	0.10	0.13	0.36	0.06	--	0.23
1 July	--	--	--	--	--	--	--	--
6 July	0.11	0.09	0.13	0.06	0.31	0.16	0.15	0.06
8 July	0.06	0.06	0.13	0.06	0.09	0.13	--	0.19
13 July	0.10	0.06	0.13	--	--	--	--	--
14 July	--	--	--	0.09	0.13	0.10	0.22	0.20
20 July	--	--	--	--	--	--	0.13	0.17
21 July	0.06	0.09	0.13	0.09	0.14	0.10	--	--
27 July	0.03	0.05	0.09	0.05	0.08	0.07	--	--
28 July	--	--	--	--	--	--	0.12	0.18
3 Aug.	0.03	0.03	0.11	0.03	--	--	0.11	0.12
10 Aug.	0.12	0.12	0.11	0.05	0.06	0.09	--	--
11 Aug.	--	--	--	--	--	--	0.11	0.13

Station Number

DATE	7	8	9	10	11	12	13	G
22 June	--	--	--	--	--	--	--	0.16
23 June	0.06	0.09	0.20	0.13	0.13	0.20	--	--
25 June	0.07	0.17	0.06	--	--	--	0.12	0.19
29 June	0.10	0.10	0.06	--	--	--	0.05	0.15
1 July	--	--	--	--	--	--	--	--
6 July	0.10	--	0.08	0.10	0.09	0.08	--	0.16
8 July	0.09	0.11	0.10	--	--	--	0.09	0.17
13 July	--	--	--	--	--	--	--	0.24
14 July	0.13	0.12	0.08	0.13	0.09	0.06	0.09	--
20 July	0.10	0.10	0.10	0.09	0.07	0.06	0.06	--
21 July	--	--	--	--	--	--	--	0.16
27 July	--	--	--	--	--	--	--	0.13
28 July	0.07	0.10	0.07	0.04	0.04	0.02	0.02	--
3 Aug.	0.04	0.67	--	--	--	--	--	0.13
10 Aug.	--	--	--	--	--	--	--	0.13
11 Aug.	0.05	0.07	0.12	0.03	0.03	0.02	0.02	--

*Omitted station 5, 25 June in statistical analysis.

TABLE 11

TOTAL DISSOLVED SOLIDS (Mg./liter $CaCO_3$)

Station Number

DATE	1	2	2A	3	4	5	6	6A
22 June	60	59	40	60	40	58	--	--
23 June	--	--	--	--	--	--	--	--
25 June	65	63	37	61	37	58	25	48
29 June	65	65	42	68	39	59	--	49
1 July	65	65	40	70	35	50	25	45
6 July	65	70	40	75	35	50	25	45
8 July	65	59	40	90	40	55	--	50
13 July	65	63	49	--	--	--	--	--
14 July	--	--	--	101	42	60	29	48
20 July	--	--	--	--	--	--	26	42
21 July	80	90	45	100	40	60	--	--
27 July	80	90	50	100	40	60	--	--
28 July	--	--	--	--	--	--	30	40
3 Aug.	83	90	50	100	--	--	30	45
10 Aug.	82	90	50	102	39	64	--	--
11 Aug.	--	--	--	--	--	--	22	43

Station Number

DATE	7	8	9	10	11	12	13	G
22 June	--	--	--	--	--	--	--	62
23 June	50	20	19	60	151	115	--	--
25 June	45	20	14	--	--	--	51	54
29 June	48	20	19	--	--	--	45	64
1 July	40	20	20	50	115	125	50	60
6 July	45	25	25	60	125	110	60	65
8 July	60	21	25	--	--	--	65	72
13 July	--	--	--	--	--	--	--	62
14 July	59	23	31	71	147	128	65	62
20 July	60	23	37	60	143	115	67	--
21 July	--	--	--	--	--	--	--	76
27 July	--	--	--	--	--	--	--	80
28 July	55	22	30	70	150	130	70	--
3 Aug.	65	25	--	--	--	--	--	90
10 Aug.	--	--	--	--	--	--	--	88
11 Aug.	70	24	38	75	153	152	87	--

TABLE 12

SUSPENDED SOLIDS (Nonfiltrable Residue, mg./liter)

Station Number

DATE	1	2	2A	3	4	5	6	6A
25 June	7	2	1	4	1	4	2	5
29 June	10	15	2	3	3	3	--	30
1 July	5	2	3	1	1	--	1	3
6 July	1	2	--	--	--	0	1	4
20 July	--	--	--	--	--	--	4	6
21 July	2	--	1	2	1	--	--	--

Station Number

DATE	7	8	9	10	11	12	13	G
25 June	2	2	3	--	--	--	0	2
29 June	17	5	9	--	--	--	0	1
1 July	1	--	--	--	--	4	--	2
6 July	--	--	--	--	2	--	--	6
20 July	0	3	3	1	7	0	2	--
21 July	--	--	--	--	--	--	--	3

TABLE 13

TURBIDITY (JACKSON TURBIDITY UNITS)

Station Number

DATE	1	2	2A	3	4	5	6	6A
23 June	--	--	--	--	--	--	--	--
25 June	51	10	5	30	7	9	9	20
29 June	10	29	2	8	11	0	--	30
1 July	9	11	8	14	12	8	8	22
6 July	10	18	10	18	20	20	15	30
8 July	11	--	5	10	15	10	--	10
13 July	9	10	7	--	--	--	--	--
14 July	--	--	--	10	7	10	10	11
20 July	--	--	--	--	--	--	13	10
21 July	10	10	7	11	11	6	--	--
27 July	5	5	4	3	15	1	--	--
28 July	--	--	--	--	--	--	10	13
3 Aug.	0	0	0	0	--	--	6	7
10 Aug.	4	5	10	8	5	10	--	--
11 Aug.	--	--	--	--	--	--	4	11

Station Number

DATE	7	8	9	10	11	12	13	G
23 June	15	21	23	12	10	8	--	--
25 June	12	13	9	--	--	--	8	10
19 June	10	19	9	--	--	--	11	10
1 July	8	8	10	7	15	7	8	11
6 July	25	10	15	10	20	8	15	10
8 July	15	10	10	--	--	--	10	6
13 July	--	--	--	--	--	--	--	3
14 July	10	9	10	11	10	9	10	--
20 July	10	10	10	12	11	10	9	--
21 July	--	--	--	--	--	--	--	3
27 July	--	--	--	--	--	--	--	3
28 July	10	19	10	7	9	5	5	--
3 Aug.	3	7	--	--	--	--	--	0
10 Aug.	--	--	--	--	--	--	--	7
11 Aug.	10	9	4	2	2	2	3	--

TABLE 14

WATER TEMPERATURE (^{o}C)

DATE	1	2	2A	3	4	5	6	6A
22 June	12	10	--	--	--	--	--	--
23 June	--	--	--	--	--	--	--	--
25 June	16	21*	11	13	9	9	12	16
29 June	10	9	8	8	7	6	--	11
1 July	13	11	9	9	7	7	8	11
6 July	17	13	8	17	10	8	13	16
8 July	12	12	8	12	8	6	--	13
13 July	15	14	14	--	--	--	--	--
14 July	--	--	--	16	9	8	12	15
20 July	--	--	--	--	--	--	15	17
21 July	16	16	9	16	9	11	--	--
27 July	14	15	10	16	10	9	--	--
28 July	--	--	--	--	--	--	12	15
3 Aug.	14	15	10	18	--	--	13	17
10 Aug.	12	13	10	18	10	8	--	--
11 Aug.	--	--	--	--	--	--	12	15

Station Number

DATE	7	8	9	10	11	12	13	G
22 June	--	--	--	--	--	--	--	--
23 June	12	12	8	8	9	9	--	7
25 June	11	12	8	--	--	--	8	10
29 June	8	8	7	--	--	--	7	7
1 July	8	9	6	6	6	9	7	9
6 July	13	12	10	9	8	11	10	7
8 July	12	13	12	--	--	--	11	6
13 July	--	--	--	--	--	--	--	9
14 July	15	15	13	12	11	8	13	--
20 July	17	17	15	13	11	11	12	--
21 July	--	--	--	--	--	--	--	9
27 July	--	--	--	--	--	--	--	8
28 July	14	14	13	12	11	13	12	--
3 Aug.	16	14	--	--	--	--	--	8
10 Aug.	--	--	--	--	--	--	--	8
11 Aug.	16	16	14	11	8	13	13	8

*Omitted Station 2, 25 June in statistical analysis.

TABLE 15

DISSOLVED OXYGEN (Mg./liter)

Station Number

DATE	1	2	2A	3	4	5	6	6A
22 June	9.8	10.2	10.9	9.3	9.9	--	--	--
23 June	--	--	--	--	--	--	--	--
25 June	8.3	8.5	11.1	10.8	11.2	10.0	8.5	7.5
29 June	9.9	10.0	9.8	9.4	9.8	10.0	--	8.3
1 July	9.5	9.8	10.2	9.7	10.4	10.3	9.6	8.8
6 July	8.7	9.4	10.7	9.0	10.0	--	8.3	7.9
8 July	8.7	9.1	10.1	9.2	10.1	10.7	--	8.6
13 July	9.5	9.4	10.4	--	--	--	--	--
14 July	--	--	--	8.7	9.8	10.3	8.9	8.5
20 July	--	--	--	--	--	--	7.9	7.9
21 July	8.8	8.6	--	8.1	9.2	9.1	--	--
27 July	8.6	8.4	9.3	7.8	8.9	9.3	--	--
28 July	--	--	--	--	--	--	8.2	7.8
3 Aug.	9.6	9.1	9.6	8.4	--	--	8.1	8.1
10 Aug.	--	9.8	9.8	8.6	9.4	9.9	--	--
11 Aug.	--	--	--	--	--	--	8.6	8.7

Station Number

DATE	7	8	9	10	11	12	13	G
22 June	--	--	--	--	--	--	--	10.8
23 June	8.3	7.7	8.8	8.9	9.1	8.1	--	--
25 June	8.8	8.5	9.2	--	--	--	9.6	11.1
29 June	9.6	9.1	9.5	--	--	--	9.8	9.9
1 July	9.4	9.2	9.6	9.8	9.6	9.2	9.9	10.0
6 July	8.2	8.1	8.4	8.9	9.1	8.6	8.9	10.3
8 July	9.2	8.7	8.9	--	--	--	9.5	--
13 July	--	--	--	--	--	--	--	10.6
14 July	8.1	7.8	8.2	8.6	8.7	8.1	8.3	--
20 July	7.8	7.8	8.0	--	9.0	8.8	8.7	--
21 July	--	--	--	--	--	--	--	9.7
27 July	--	--	--	--	--	--	--	9.6
28 July	8.3	8.0	7.9	8.6	8.6	8.2	8.5	--
3 Aug.	7.8	7.9	--	--	--	--	--	9.9
10 Aug.	--	--	--	--	--	--	--	10.4
11 Aug.	8.4	8.3	8.5	9.1	9.7	9.1	9.0	--

TABLE 15A

DISSOLVED OXYGEN (PERCENT SATURATION)

DATE	Station Number 1	2	2A	3	4	5	6	6A
22 June	1.034	1.042	--	--	--	--	--	--
23 June	--	--	--	--	--	--	--	--
25 June	0.950	--	1.154	1.210	1.138	1.011	0.959	0.906
29 June	1.005	1.004	0.961	0.950	0.960	0.951	--	0.910
1 July	1.017	1.016	1.009	0.989	1.004	0.989	0.984	0.950
6 July	1.020	1.025	1.040	1.101	1.054	--	0.960	0.957
8 July	0.916	0.970	0.981	1.011	1.005	1.008	--	0.976
13 July	1.065	1.045	1.156	--	--	--	--	--
14 July	--	--	--	1.031	0.988	1.009	0.996	0.997
20 July	--	--	--	--	--	--	0.956	0.979
21 July	1.014	1.004	--	0.975	0.942	0.971	--	--
27 July	0.950	0.960	0.951	0.938	0.932	0.947	--	--
28 July	--	--	--	--	--	--	0.933	0.931
3 Aug.	1.054	1.034	0.976	1.047	--	--	0.935	1.000
10 Aug.	--	1.063	0.993	1.068	0.975	0.975	--	--
11 Aug.	--	--	--	--	--	--	0.970	1.028

DATE	Station Number 7	8	9	10	11	12	13	G
22 June	--	--	--	--	--	--	--	--
23 June	0.931	0.868	0.911	0.921	0.982	0.877	--	--
25 June	0.962	0.955	0.950	--	--	--	0.991	1.142
29 June	0.991	0.943	0.969	--	--	--	0.999	0.959
1 July	0.955	0.962	0.940	0.960	0.956	0.990	0.994	1.002
6 July	0.941	0.931	0.912	0.944	0.959	0.976	0.966	0.989
8 July	1.032	1.002	1.011	--	--	--	1.055	--
13 July	--	--	--	--	--	--	--	1.066
14 July	0.960	0.928	0.942	0.966	0.972	0.847	0.953	--
20 July	0.976	0.980	0.972	--	1.019	1.000	0.990	--
21 July	--	--	--	--	--	--	--	0.982
27 July	--	--	--	--	--	--	--	0.948
28 July	0.979	0.948	0.923	0.983	0.978	0.979	0.972	--
3 Aug.	0.952	0.928	--	--	--	--	--	0.972
10 Aug.	--	--	--	--	--	--	--	1.018
11 Aug.	1.025	1.017	1.006	1.007	1.018	1.076	1.042	--

TABLE 16

TIME SAMPLES COLLECTED

Station Number

DATE	1	2	2A	3	4	5	6	6A
22 June	0930	1135	1145	1350	1435	1605	--	--
23 June	--	--	--	--	--	--	--	--
25 June	1815	1620	1635	1300	1345	1510	1405	1315
29 June	1855	1750	1750	1515	1430	1240	--	1420
1 July	1655	1522	1530	1115	1245	1420	1530	1435
6 July	1830	1115	1130	1550	1450	1305	1530	1440
8 July	0715	0820	0825	1050	1015	0915	--	1005
13 July	1550	1830	1845	--	--	--	--	--
14 July	--	--	--	1500	1417	1140	1635	1540
20 July	--	--	--	--	--	--	1645	1555
21 July	1215	1345	1350	1720	1530	1640	--	--
27 July	1048	1255	1313	1735	1640	1445	--	--
28 July	--	--	--	--	--	--	1835	1735
3 Aug.	1145	1340	1400	1645	--	--	1845	1740
10 Aug.	0950	1230	1300	1645	1600	1430	--	--
11 Aug.	--	--	--	--	--	--	1720	1625

Station Number

DATE	7	8	9	10	11	12	13	G
22 June	--	--	--	--	--	--	--	1105
23 June	1530	1445	1420	1340	1140	1300	--	--
25 June	1240	1155	1100	--	--	--	1130	1715
29 June	1350	1330	1250	--	--	--	1315	1810
1 July	1355	1400	1315	1230	1045	1145	1250	1605
6 July	1410	1400	1315	1245	1115	1200	1330	1025
8 July	1050	1115	1227	--	--	--	1255	0750
13 July	--	--	--	--	--	--	--	1630
14 July	1745	1800	1905	2000	2100	2145	1835	--
20 July	1520	1505	1310	1415	1230	1325	1240	--
21 July	--	--	--	--	--	--	--	1305
27 July	--	--	--	--	--	--	--	1140
28 July	1655	1635	1440	1540	1150	1320	1410	--
3 Aug.	2010	2040	--	--	--	--	--	1250
10 Aug.	--	--	--	--	--	--	--	1120
11 Aug.	1545	1530	1440	1340	1100	1215	1410	--

TABLE 17

BACTERIOLOGICAL (Per 100 ml.)

Sta.	Date	Total Coliform	Fecal Coliform	Fecal Streptococcus	Total Bacteria
1	22 June	26		0	
	30 June			0	
	8 July	14			808
	13 July	36	0		
	22 July	29			
2	22 June	17		0	
	30 June	18		0	
	8 July	5			304
	13 July	35	0		
	22 July	24			
3	22 June	28		0	
	30 June	34		0	
	8 July	6			
	13 July	25	0		
	22 July	34			
7	23 June	37		0	
	25 June	44		0	
	8 July	29			200
	13 July	25	0		

TABLE 18

BOTTOM SAMPLES
BIOMASS (grams/sq. ft.)

Station Number

DATE	1	2	2A	3	4	5	6	6A
10 Aug.	1.91	3.70	1.92	1.52	0.13	1.32	--	--
10* Aug.	0.43	--	0.96	0.89	0.24	1.54	--	--
12 Aug.	--	--	--	--	--	--	0.46	0.42
12* Aug.	--	--	--	--	--	--	0.40	0.21

Station Number

DATE	7	8	9	10	11	12	13	G
10 Aug.	--	--	--	--	--	--	--	--
10* Aug.	--	--	--	--	--	--	--	--
12 Aug.	3.29	0.50	0.19	0.64	0.35	0.40	0.76	1.18
12* Aug.	2.78	0.69	--	0.31	0.46	0.44	0.42	0.36

* Indicates bottom samples taken from middle of stream.

TABLE 19

BOTTOM SAMPLES

	1	2	2A	3	4	5	6	6A
Ephemeroptera Heptageniidae	*		*		*	*	*	*
Ephemeroptera Baetidae	*		*			*	*	
Ephemeroptera Other					*		*	*
Trichoptera Rhyacophilidae	*	*	*			*		
Trichoptera Hydropsychidae		*						
Trichoptera Other	*	*	*	*			*	
Neuroptera Larvae		*						

	7	8	9	10	11	12	13	G
Ephemeroptera Heptageniidae			*	*	*	*		
Ephemeroptera Baetidae					*			*
Ephemeroptera Other			*	*	*	*		
Trichoptera Rhyacophilidae							*	*
Trichoptera Other	*				*			
Neuroptera Larvae				*				

TABLE 19 (Cont'd)

BOTTOM SAMPLES

	1	2	2A	3	4	5	6	6A
Diptera Larvae	*	*		*		*		
Coleoptera Dytiscidae	*	*		*				
Coleoptera Larvae		*		*				
Plecoptera Larvae	*	*		*		*	*	*
Plecoptera Eggs			*					
Mollusca			*					
Nematodes		*					*	
Platyhelminthes "Planaria"								

	7	8	9	10	11	12	13	G
Diptera Larvae		*	*					
Coleoptera Dytiscidae		*				*		
Coleoptera Larvae						*		*
Plecoptera Larvae	*		*	*			*	*
Plecoptera Eggs								
Mollusca								*
Nematodes		*					*	*
Platyhelminthes "Planaria"						*		

The following test results were not reported on data sheets because results obtained were not within the precision of the procedure (as described in Standard Methods for the Examination of Water and Wastewater) used.

CHLORIDES: The mecuric nitrate method was used. The precision of this test as set forth in Standard Methods is ± 1.1 mg/liter. All results obtained were below 1 mg/liter with the exception of one sample from one station. This sample was from station 8 on 23 June, 1970 and was 1.2 mg/liter chlorides. Since all other results from this station were non-detectable, it is felt that the results for 23 June, 1970, are non-valid. Chlorides were in all cases, less than 1.1 mg/liter.

NITRITES: Nitrite tests were conducted according to the nitrogen (nitrite) method listed under the section on water in Standard Methods. The precision for this test is ± 0.02 mg/liter. In all cases, nitrites were below 0.02 mg/liter.

BIOCHEMICAL OXYGEN DEMAND: The purpose of determining the biochemical oxygen demand was to obtain a ratio between the COD and BOD of the water. For this reason BOD was only analyzed enough times to indicate a trend.

The tests were conducted according to procedures in Standard Methods for the Examination of Water and Wastewater. As mentioned previously in this report, the BOD of the water was below the statistical limits of reliability for the procedure used. The BOD of the water was below 2 mg/liter in all cases.

TABLE 20

HEAVY METALS

Silver

Sta. No.	mg/liter	Date of Sampling
1	0.01	16 Aug. 1970
7	0.01	16 Aug. 1970
11	0.02	16 Aug. 1970
13	0.03	16 Aug. 1970

Manganese

Sta. No.	mg/liter (less than)	Date of Sampling
1	0.05	3 Aug. 1970
2	0.05	3 Aug. 1970
2A	0.05	3 Aug. 1970
3	0.05	3 Aug. 1970
6	0.05	3 Aug. 1970
6A	0.05	3 Aug. 1970
7	0.05	3 Aug. 1970
8	0.05	3 Aug. 1970
Griz.	0.05	3 Aug. 1970
1	0.05	16 Aug. 1970
7	0.05	16 Aug. 1970
11	0.05	16 Aug. 1970
13	0.05	16 Aug. 1970

Copper

Sta. No.	mg/liter (less than)	Date of Sampling
1	0.03	27 July 1970
2	0.03	27 July 1970
2A	0.02	27 July 1970
3	0.03	27 July 1970
4	0.02	27 July 1970
5	0.03	27 July 1970
6	0.02	27 July 1970
6A	0.02	27 July 1970
7	0.03	27 July 1970
8	0.02	27 July 1970
9	0.02	27 July 1970
10	0.02	27 July 1970
11	0.02	27 July 1970
12	0.02	27 July 1970
13	0.02	27 July 1970
Griz.	0.03	27 July 1970

TABLE 21

TANNIN AND LIGNIN

Sta. No.	mg/liter	Date of Sampling
1	0.2	27 July 1970
2	0.1	27 July 1970
2A	0.2	27 July 1970
3	0.2	27 July 1970
4	0.4	27 July 1970
5	0.0	27 July 1970
6	0.5	28 July 1970
6A	1.0	28 July 1970
7	0.4	28 July 1970
8	0.5	28 July 1970
9	0.1	28 July 1970
10	0.3	28 July 1970
11	0.4	28 July 1970
12	0.2	28 July 1970
13	0.4	28 July 1970
G	0.4	28 July 1970
1	0.5	28 July 1970
2	0.5	28 July 1970
2A	0.4	28 July 1970
3	0.5	28 July 1970
6	0.5	28 July 1970
6A	0.7	28 July 1970
7	0.5	28 July 1970
8	0.7	28 July 1970
G	0.4	27 July 1970

TABLE 22

STATISTICAL SUMMARY

Total Alkalinity

Statistics	Station Number 1	2	2A	3	4	5	6	6A
No. of Samples	11	11	11	11	10	10	8	10
Mean	50.2	52.2	32.0	58.7	30.4	36.8	15.5	28.2
Range	14	14	18	36	18	18	8	10
Median	52	52	32	60	29	36	15	29

Statistics	Station Number 7	8	9	10	11	12	13	Griz.
No. of Samples	11	11	10	7	7	7	9	11
Mean	38.2	13.5	16.4	44.6	105.1	94.0	43.1	49.9
Range	26	8	16	22	42	30	32	33
Median	38	14	16	44	108	88	44	50

COD (Mg/liter)

Statistics	Station Number 1	2	2A	3	4	5	6	6A
No. of Samples	10	10	10	10	9	9	8	9
Mean	7.69	7.61	2.77	6.69	8.98	6.57	10.74	16.31
Range	18.7	15.8	7.0	11.8	13.1	15.7	27.2	22.4
Median	6.9	6.2	2.2	6.2	9.0	6.1	6.8	16.3

Statistics	Station Number 7	8	9	10	11	12	13	G
No. of Samples	10	10	9	7	7	7	8	10
Mean	11.25	12.68	12.71	6.23	7.59	4.53	4.96	3.11
Range	18.8	25.7	16.8	12.1	8.0	14.6	9.7	7.7
Median	11.0	12.4	12.8	6.3	7.5	3.4	4.5	2.2

TABLE 22 (cont'd)

STATISTICAL SUMMARY

Total Hardness (Mg/liter as $CaCO_3$)

Statistics	Station Number 1	2	2A	3	4	5	6	6A
No. of Samples	11	11	11	11	10	10	8	10
Mean	53.2	55.0	32.0	60.9	28.5	35.4	16.2	29.3
Range	34	40	14	33	19	14	11	13
Median	54	54	32	64	25.5	36	17.5	29.5

Statistics	Station Number 7	8	9	10	11	12	13	G
No. of Samples	11	11	10	7	7	7	9	11
Mean	39.7	14.7	17.5	47.9	112.4	101.0	45.8	47.9
Range	34	18	22	27	37	32	28	41
Median	40	15	18	46	115	99	44	47

Ammonia (Mg/liter Ammonia Nitrogen)

Statistics	Station Number 1	2	2A	3	4	5	6	6A
No. of Samples	11	11	11	11	10	10	8	10
Mean	.055	.061	.006	.065	.080	.020	.074	.23
Range	.11	.14	.03	.07	.13	.10	.14	.29
Median	.05	.07	0.00	.06	.08	.01	.085	.245

Statistics	Station Number 7	8	9	10	11	12	13	G
No. of Samples	11	11	10	7	7	7	9	11
Mean	.101	.194	.167	.056	.037	.016	.030	.012
Range	.08	.41	.30	.27	.06	.07	.06	.07
Median	.11	.17	.175	.02	.04	0.00	.03	0.00

TABLE 22 (cont'd)

STATISTICAL SUMMARY

Nitrate (Mg/liter Nitrate Nitrogen)

Statistics	Station Number 1	2	2A	3	4	5	6	6A
No. of Samples	9	11	11	10	9	10	8	8
Mean	.04	.05	.03	.07	.06	.07	.04	.08
Range	.2	.4	.2	.6	.4	.4	.2	.3
Median	.00	.00	.00	.00	.00	.00	.00	.00

Statistics	Station Number 7	8	9	10	11	12	13	G
No. of Samples	11	11	9	6	7	7	8	10
Mean	.05	.05	.07	0.0	.03	.06	.05	.08
Range	.3	.3	.2	0.0	.2	.3	.3	.5
Median	.00	.00	.00	.00	.00	.00	.00	.00

pH

Statistics	Station Number 1	2	2A	3	4	5	6	6A
No. of Samples	8	7	8	8	7	7	5	6
Mean	8.19	8.19	7.96	8.20	7.99	8.10	7.50	7.65
Range	2.1	0.6	0.9	0.9	1.1	1.4	0.2	0.4
Median	8.1	8.3	7.9	8.25	7.9	8.0	7.5	7.7

Statistics	Station Number 7	8	9	10	11	12	13	G
No. of Samples	7	7	6	5	5	5	5	8
Mean	8.06	7.61	7.65	8.04	8.42	8.44	8.04	7.89
Range	0.6	1.1	1.6	0.4	0.8	1.0	0.3	0.6
Median	8.0	7.5	7.5	8.0	8.3	8.4	8.1	8.0

TABLE 22 (cont'd)

STATISTICAL SUMMARY

Total Phosphate (Mg/liter PO_4)

Statistics	Station Number 1	2	2A	3	4	5	6	6A
No. of Samples	10	10	10	10	9	8	7	9
Mean	.080	.091	.128	.069	.147	.102	.139	.160
Range	.10	.17	.10	.10	.30	.09	.11	.11
Median	.08	.09	.13	.06	.08	.10	.13	.17

Statistics	Station Number 7	8	9	10	11	12	13	G
No. of Samples	10	9	9	6	6	6	7	10
Mean	.081	.170	.097	.087	.075	.073	.064	.162
Range	.09	.60	.14	.10	.10	.18	.10	.11
Median	.07	.12	.08	.095	.08	.06	.06	.16

Total Dissolved Solids (Mg/liter $CaCO_3$)

Statistics	Station Number 1	2	2A	3	4	5	6	6A
No. of Samples	11	11	11	11	10	10	8	10
Mean	72.3	73.1	43.9	84.3	38.7	57.4	26.5	45.5
Range	25	31	13	42	7	14	8	10
Median	65	65	42	90	40	58.5	25.5	45

Statistics	Station Number 7	8	9	10	11	12	13	G
No. of Samples	11	11	10	7	7	7	9	12
Mean	54.3	22.1	25.8	63.7	140.6	125.0	62.2	69.6
Range	30	5	24	25	38	42	42	36
Median	55	22	25	60	147	125	65	64.5

TABLE 22 (cont'd)

STATISTICAL SUMMARY

Suspended Solids (Nonfiltrable Residue, Mg/liter)

	Station Number							
Statistics	1	2	2A	3	4	5	6	6A
No. of Samples	5	4	4	4	4	3	4	5
Mean	5.0	5.25	1.75	2.5	1.5	2.3	2.0	11.6
Range	9	13	2	3	2	4	3	27
Median	5	2	15	2.5	1	3	1.5	5

	Station Number							
Statistics	7	8	9	10	11	12	13	G
No. of Samples	4	3	3	1	2	2	3	5
Mean	5.0	3.3	5.0	1.0	4.5	2.0	.7	2.8
Range	17	3	6	0	5	4	2	5
Median	1.5	3	3	1	4.5	2.0	0	2

Turbidity (Jackson Turbidity Unit)

	Station Number							
Statistics	1	2	2A	3	4	5	6	6A
No. of Samples	10	9	10	10	9	9	8	10
Mean	11.9	10.9	6.5	11.2	11.4	8.2	9.4	16.4
Range	51	29	10	30	15	19	11	23
Median	9.5	10	6	10	11	9	9.5	12

	Station Number							
Statistics	7	8	9	10	11	12	13	G
No. of Samples	11	11	10	7	7	7	9	10
Mean	11.6	12.3	11.0	8.7	11.0	7.0	8.8	6.3
Range	22	14	19	10	18	8	12	--
Median	10	10	10	10	10	8	9	--

TABLE 22 (Cont'd)

STATISTICAL SUMMARY

Water Temperature (°C)

Statistics	Station Number 1	2	2A	3	4	5	6	6A
No. of Samples	11	10	10	10	9	9	8	10
Mean	13.7	12.8	9.7	14.3	8.8	8.0	12.1	14.6
Range	7	7	6	10	3	5	7	6
Median	14	13	9.5	16	9	8	12	15

Statistics	Station Number 7	8	9	10	11	12	13	G
No. of Samples	11	11	10	7	7	7	9	12
Mean	12.9	12.9	10.6	11.6	9.1	10.6	10.3	8.0
Range	9	9	9	7	5	5	6	4
Median	13	13	11	11	9	11	11	8

Dissolved Oxygen (Mg/liter)

Statistics	Station Number 1	2	2A	3	4	5	6	6A
No. of Samples	10	11	10	11	10	8	8	10
Mean	9.14	9.30	10.19	9.00	9.88	9.95	8.51	8.21
Range	1.6	1.8	1.8	3.0	2.3	1.6	1.7	1.3
Median	9.2	9.4	10.15	9.0	9.85	10.0	8.4	8.2

Statistics	Station Number 7	8	9	10	11	12	13	G
No. of Samples	11	11	10	6	7	7	9	10
Mean	8.54	8.28	8.70	8.98	9.11	8.59	9.13	10.23
Range	1.8	1.5	1.7	1.2	1.1	1.1	1.6	1.5
Median	8.3	8.1	8.6	8.9	9.1	8.6	8.9	10.15

TABLE 22 (Cont'd)

STATISTICAL SUMMARY

Dissolved Oxygen (Percent Saturation)

Statistics	Station Number 1	2	2A	3	4	5	6	6A
No. of Samples	10	10	9	10	9	8	8	10
Mean	1.003	1.016	1.024	1.032	1.000	0.983	0.962	0.963
Range	0.149	0.103	0.205	0.272	0.206	0.064	0.063	0.122
Median	1.016	1.021	0.993	1.021	0.988	0.982	0.960	0.967

Statistics	Station Number 7	8	9	10	11	12	13	G
No. of Samples	11	11	10	6	7	7	9	9
Mean	0.973	0.951	0.954	0.964	0.983	0.964	0.996	1.009
Range	0.101	0.149	0.100	0.086	0.063	0.229	0.102	0.194
Median	0.962	0.948	0.946	0.963	0.978	0.979	0.991	0.989

TABLE 23

SMITH-SATTERTHWAITE SAMPLE t TEST
Stations 4&5

		X Sample Mean	S Sample Standard Deviation	t'Statistic	$t_{\alpha/2}$
Total Phosphate	Sta. 4	0.147	0.112	1.157	2.262
	Sta. 5	0.102	0.032		
Total Hardness	Sta. 4	28.5	5.95	2.997	2.120
	Sta. 5	35.4	4.20		
Total Dis. Solids	Sta. 4	38.7	2.31	11.69	2.160
	Sta. 5	57.4	4.50		
Chemical Ox. Demand	Sta. 4	8.98	3.77	1.147	2.131
	Sta. 5	6.57	5.05		
Nitrate Nitrogen	Sta. 4	0.0556	0.157	0.219	2.131
	Sta. 5	0.070	0.125		
Ammonia Nitrogen	Sta. 4	0.080	0.037	3.846	2.110
	Sta. 5	0.020	0.031		
Total Alkalinity	Sta. 4	30.4	5.95	2.479	2.101
	Sta. 5	36.8	5.59		
Turbidity	Sta. 4	11.4	4.75	1.275	2.131
	Sta. 5	8.2	5.85		
pH	Sta. 4	7.99	0.358	0.482	2.201
	Sta. 5	8.10	0.487		
Percent Saturation Dissolved Oxygen	Sta. 4	1.000	0.064	0.486	2.145
	Sta. 5	0.983	0.078		

TABLE 24

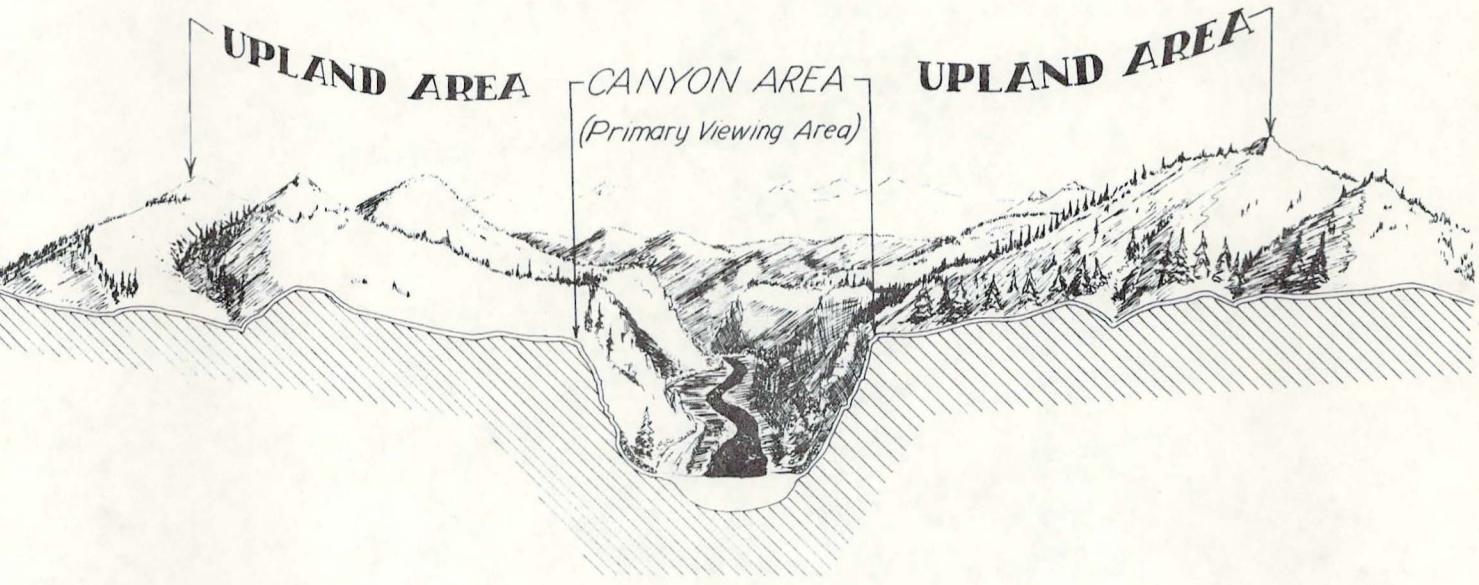
SMITH-SATTERTHWAITE SAMPLE t TEST
Stations 8&9

		X Sample Mean	S Sample Standard Deviation	t'Statistic	tα/2
Total Phosphate	Sta. 8	0.170	0.189	1.127	2.262
	Sta. 9	0.097	0.044		
Total Hardness	Sta. 8	14.7	4.78	1.051	2.120
	Sta. 9	17.5	7.09		
Total Dis. Solids	Sta. 8	22.1	2.02	1.411	2.228
	Sta. 9	25.8	8.07		
Chemical Ox. Demand	Sta. 8	12.68	6.53	0.011	2.110
	Sta. 9	12.71	5.37		
Nitrate Nitrogen	Sta. 8	0.05	0.103	0.506	2.110
	Sta. 9	0.07	0.073		
Ammonia Nitrogen	Sta. 8	0.194	0.114	0.616	2.101
	Sta. 9	0.167	0.085		
Total Alkalinity	Sta. 8	13.5	2.98	1.452	2.160
	Sta. 9	16.4	5.64		
Turbidity	Sta. 8	12.3	5.00	0.597	2.093
	Sta. 9	11.0	4.97		
pH	Sta. 8	7.61	0.358	0.146	2.306
	Sta. 9	7.65	0.582		
Percent Saturation Dissolved Oxygen	Sta. 8	0.951	0.039	0.184	2.101
	Sta. 9	0.954	0.036		

APPENDIX IV

FOREST SERVICE BROCHURE ON ROCK CREEK

TYPICAL CROSS SECTION OF THE LOWER ROCK CREEK DRAINAGE



FOREST SERVICE MANAGEMENT DIRECTION (PROPOSED)

1. Recognize water as the primary resource in the entire area. Manage all other resources to protect or enhance water quality & quantity.

a) Manage the Canyon Area primarily for recreation & esthetic value.

b) Manage the Upland Area for the production of renewable resources, such as timber, forage & wildlife.

SUMMARY ROCK CREEK DRAINAGE
DEERLODGE AND LOLO FORESTS

General Information	
Total Area	569,535 acres
National Forest	457,800 acres
Private	94,325 acres
State	4,890 acres
B.L.M.	12,520 acres
Roads and Mileage	
Main Rock Creek Road	
Interstate 90 to Skalkaho Road	51.5 miles
Existing Access Roads	100.0 miles
Water Resource	
Blue Ribbon Stream	55.0 miles
Total Fishable Stream	282.0 miles
Streams Classified by Montana State	
Fish and Game Department	155.5 miles
Recreation Resource	
Existing Areas	
Forest Service Campgrounds	12
Number of Units	108
State Campgrounds (Limited Facilities)	1
Private Camps	
Elkhorn Ranch	
Number of Units	35
Capacity	175 people
Use	
Visitor Days	159,600
Timber Resource	
Total Sawtimber Volume	1,372,000,000 board feet
Tentative Periodic Annual Allowable Cut	30 million board feet
Range Resource	
Range Suitable for Domestic Livestock	41,565 acres
Number of Grazing Permits	19
Number of Permitted Cattle	1,553
Wildlife Resource	
National Forest acreage of Key Big-Game	
Winter Range	24,000 acres

Basic Facts Concerning the Upper Portion of Rock Creek (Deerlodge N.F.) (above Gilles Bridge)

I. General Information		Acres
Total Planning Area		336,050
Ownership Breakdown:		
Area Inside Forest Boundary		260,250
National Forest Land	248,015	
Private Land	11,915	
State Land	320	
Area Outside Forest Boundary		75,800

II. Roads and Mileages	
Main Rock Creek Road	
Gillies Bridge to Skalkaho Road	7.5
Skalkaho State Highway	
Rock Creek - Flint Creek Divide to Rock Creek	6.0
Rock Creek to Skalkaho Pass	16.0
Main Access Roads in Upper Rock Creek	
Upper Willow Creek (County Road 9 miles)	20.0
East Fork (County Road)	6.0
Middle Fork	11.0
Ross Fork (County Road)	4.0
Marshall Creek	7.0

III. Water Resource	
Blue Ribbon Stream	7.0
Total Fishable streams Surveyed	185.0
Streams Classified by Montana Fish & Game	96.5

Stream Habitat Surveys

Survey stations were established in 13 creeks with five or more miles of fishable stream. This amounted to 110 stations in 14.5 miles. In addition to those stations 17 minor streams (creeks with less than five miles of fishable stream) were surveyed. This amounts to a total of 152 stations on 185 miles of 30 streams.

IV. Recreation Resource

The major portion of Upper Rock Creek on the Philipsburg District runs through private lands. Thus, most of the recreation visits are made to the tributaries of Rock Creek rather than Rock Creek itself. Opportunities for recreation are similar with those of lower Rock Creek - fishing, hunting, camping, picnicking, hiking, horseback and scooter riding, snowmobile use, driving for pleasure, nature studies, and boating.

Upper Rock Creek is much different than lower Rock Creek in that once upstream from Gillies Bridge the narrow canyon opens up into more gentle, rolling terrain. The bributaries all head up in high elevation alpine country of elevations near 10,000 feet and provide spectacular scenery.

Four developed campgrounds are located on tributaries of Rock Creek. There are no private camping facilities developed along the main Rock Creek.

Existing Facilities

Forest Service Campgrounds	4
Number of Units	28

In the 1960 National Forest Recreation Survey (NFRS) numerous potential recreation sites were inventoried along the various tributaries of Rock Creek.

The headwaters of Rock Creek contain 39,967 acres of land that is classified as wilderness. The majority of this portion of the Anaconda-Pintlar Wilderness is high alpine country ranging from 6,000 to 10,000 foot elevation. This area has access by trail only and is managed under guidelines set up in the Wilderness Act of 1964.

Recreation Use - 1969

Visitor Days; Campgrounds	9,700
Visitor Days; Wilderness Area	8,700
Visitor Days; Recreation Residence	2,800
Visitor Days; Fishing, Boating, Driving, etc.	47,800 *
Total Visitor Days	69,000

* This figure is an estimate since our recording procedure does not separate Rock Creek from the rest of the District.

V. Timber Resource

The timber resource for the Deerlodge National Forest in Rock Creek drainage (Includes Stoney Creek of lower planning area)

Ponderosa pine	500,000 Bd. ft.
Douglas-fir	139,895,000 Bd. ft.
Spruce-Alpine fir	226,363,000 Bd. ft.
Lodgepole pine - white limber pine	336,235,000 Bd. ft.
Total sawtimber volume	702,993,000 Bd. ft.

Minus volume now in Multiple Use Zoning (high area zone) and area in stream side protection strips.

High area zone volume	50,645,000 Bd. ft.
Stream side protection strips	75,039,000 Bd. ft.
Total volume to be deducted	125,684.000 Bd. ft.

Sawtimber inventory that tentative present periodic allowable cut is based on	577,309,000 Bd. ft.
Tentative periodic allowable cut	15 million Board feet

Timber sales presently under contract in Upper Rock Creek:

Sale	Date Sold	Volume Sold	Volume Left To Be Removed
Green Canyon	9/5/56	16,300 MBF	5,000 MBF
Mud Lake	8/28/59	13,340	0
Sand Basin	6/23/65	7,900	1,000
Montgomery Gulch	1/4/68	8,930	3,000
Senate Creek	11/27/68	6,130	5,500
Medicine Lake Bench	12/11/68	11,670	11,670
Sand Basin #2	10/21/69	5,060	5,060
Coal Creek	12/3/69	5,790	5,500
West Fork	1/6/70	14,800	14,800
Miners Gulch	12/12/68	6,600	6,600
		96,520	58,130

Proposed timber sales in Upper Rock Creek for next 5 years:

Sale	Date to be Sold	Volume to be Sold
North McDougal	FY-71	2,000 MBF
Puller Gulch	FY-72	3,000
Sapphire	FY-72	3,500
Elk Creek	FY-72	3,000
Upper Willow Creek	FY-73	5,600
Frog Pond Basin	FY-73	9,500
Standish Creek	FY-74	5,500
South Senate Creek	FY-74	3,500
Squaw Creek	FY-74	5,000
Stony Mtn.	FY-75	5,000
Moose Mtn.	FY-75	10,000

Proposed road construction in conjunction with above sales:

Main haul roads	56 miles	(approximate)
Spur roads	167 miles	(approximate)

Existing roads constructed in conjunction with timber sales:

Main haul roads	36 miles	(approximate)
Spur roads	113 miles	(approximate)

VI RANGE RESOURCE

Upper Rock Creek contains 21,565 acres of National Forest land suitable for use by domestic livestock. In addition to this, there are 3,464 acres of private land under National Forest management or a total of 25,029 acres of suitable land. There are 15 grazing permits with 1,337 cattle on Forest land and six grazing permits on private land with 222 cattle. Nine range allotments are involved in Upper Rock Creek of which five are under intensive management. All nine allotments are planned to be under intensive management in the next 5 years.

VII WILDLIFE

There are approximately 4,000 acres of key winter range on National Forest land and approximately 12,000 acres on private land. The Forest land elk range is generally in fair to good condition while the private land is in poor to fair condition due to the moderate to heavy use by cattle.

Big-game animals listed in descending order of occurrance are: mule deer, elk, mountain goat, whitetail deer, moose, black bear, and big horn sheep. There are numerous fur bearers throughout the area including coyote, mountain lion, and bob cat. Ruffed, blue, and Franklin grouse are common to the area.

The trends of elk population are estimated to be slightly up and mule deer down according to State Fish and Game biologists.

Species of fish found in Upper Rock Creek and its tributaries are as follows: Eastern Brook, Cutthroat, Rainbow, Dolly Varden, and Whitefish. In addition to the above species, Grayling are found in Fuse Lake.

VIII MINERALS RESOURCE

Earliest records of prospecting in Upper Willow Creek date back to 1868. Gold mining peaked in the 1870's and 1880's with some limited prospecting continuing into the 1920's. Mining consisted mainly of placer operations.

Ross Fork, the Middle Fork, and the East Fork drainages were prospected in the 1880's and 1890's. Although there were some placer operations, the majority of the mining was quartz lode claims, some of which became patented lands. Claims in the Moose Lake area were used up into the 1930's with power being provided by water.

The Sapphire Mines in the West Fork drainage are the most extensive placer workings in the area. This area is still producing stones, some of which are of gem quality. A system of flumes and ditches tapped every important water source along the Skalkaho Divide for this operation.

Basin Gulch, Quartz Gulch, and Cornish Gulch were mined for gold in the 1890's using a hydraulic mining operation. Prospectors still work this area.

Present mining operations on patented claims are at a standstill with the economics being what they are today. Owners of patented claims realize the value of their lands for recreational development as they are frequently approached by private individuals and development companies looking for summer home sites.

Prospecting and claim staking in Upper Rock Creek is still very active with people speculating that the price of silver will rise. Large mining companies, such as the Bear Creek Mining Company, have been carrying on exploration operations in the area.

BASIC FACTS CONCERNING THE LOWER ROCK CREEK PLANNING AREA

(Interstate 90 to Gilles Bridge)

General Information		Acres
Total Planning Area		233,485
Ownership Breakdown	Forest Service - Lolo N.F.	182,000
	- Deerlodge N.F.	27,785
	Bureau of Land Management	3,300
	State	1,400
	Private Ownership	19,000
Zone Breakdown	High Area	25,200
	Canyon Area	43,500
	General Forest	164,785

Roads and Mileages		Miles
Main Rock Creek Road		
	I-90 to Ranch Creek	12
	Ranch Creek to Gilles Bridge	32
Access roads presently existing from Rock Creek Road to upland areas:		
	Brewster Creek	10
	Ranch Creek	3
	Butte Cabin Creek	1
	Gilbert Creek (private road)	5
	Stoney Creek	7
	Cornish Gulch	4

Water Resource		
Blue ribbon stream		48 miles
Total fishable streams surveyed		97
Streams classified by Montana Fish and Game Department		59
Information pertaining to stream measuring devices:		
Crest stage gauges		3
Recording dates: earliest 9/63 - latest 5/67		
Discharge measurements (point in time samples)		
Number of streams		20
Number of measurements		166+
Recording dates: earliest 6/62 - latest 9/67		

Turbidity measurements (point in time samples)

Number of streams	18
Number of measurements	152
Recording dates: earliest - 6/62; latest - 9/67	

Temperature Measurements

During 1969 continuous water temperature measurements were obtained at four locations for 2 months and at one location for 5 months beginning in August.

Stream Habitat Surveys

These surveys consisted of taking measurements and photographs at given intervals along a stream to evaluate the fish habitat in quantitative terms and to establish a measure of present conditions for future reference. Permanent stations were established at 42 points along the main Rock Creek and at one to four stations on each of 19 tributary streams. Surveys were taken on tributaries from the mouth to a point where the stream narrowed to 4 feet in width. Such items as pool-riffle ratios, type of bottom materials, bank cover, and stability were measured and evaluated. Pollution sources, fish barriers, water diversions, bridges, and opportunities for habitat improvements were noted as the crews walked the entire length of the streams between stations.

Catachable game fish found within the planning area include rainbow, brook, cutthroat, Dolly Varden, and brown trout, and mountain whitefish.

Soils

Soils in the area are generally of the highly stable Belt Series with occasional stringers of granitic soils running from west to east across the drainage. The Belt soils have been classified as low-erosion hazard with little tendency to slide or slump. The granitics are classified as medium erosion hazard with little tendency to slump.

On November 14, 1968, a cursory ground inspection of the Rock Creek bottom lands from Ranch Creek to Gilles Bridge was completed by Soil Scientist Dick Alvis. The following is a summary of his report:

> From Ranch Creek to Bobcat Creek the soils on flat stream terraces are well drained, nonplastic cobbly loams to very fine sandy loams. The underlying strata appears to be hard, well-fractured competent limestones and/or quartzites. Sections of the side slopes are gentle to moderately steep sloping talus fields.

From Bobcat Creek to a distance of 1.4 miles south, the soils are derived from granitics. Nearly all of these soils are very deep, very cobbly, single grain, loose loamy sands with sandy loam surfaces about 6 inches thick. Hard granitic cobbles account for about 50 percent of the soil mass of the subground. These soils occur on gently sloping lower colluvial-like slopes.

From a point 1.4 miles south of Bobcat Creek to Sheep Gulch, the valley bottom is for the most part made up of flat typically wide terraces of shallow gravelly loams. Beneath these shallow loams, hard well-fractured limestones, quartzites, or sandstone bedrock occurs. Portions of the side slopes are again talus fields.

South of Sheep Gulch to Gilles Bridge, the soil is deep and well-drained cobbly loams to fine sandy loams. In the vicinity of Basin and Cornish Gulches, road cuts show gravelly loams 1 to 2½ feet thick overlying very thick deposits of moderately well graded hard angular limestone gravels.

The upland soils, including colluvium, occurring above and adjacent to the stream terraces are considered to have relatively low erosion and mass-failure hazards except for these derived from granitics. The soils of granitic origin are considered to have moderate erosion hazards and low mass-failure hazards.

Recreation Resource

Rock Creek is the main attraction for the recreationist. The majority of recreation use is spent on the high-quality fishing provided by the stream. Other recreational opportunities include camping, picnicking, hunting, hiking, horseback and scooter riding, oversnow vehicle trips, driving for pleasure and nature studies. There are 25,227 acres of high area delineated along the Bitterroot Divide and in the Quigg Peak areas within the planning area.

Existing Facilities in the area:

Forest Service campground and picnic sites	8
Number of units	80
State campground (limited facilities)	1
Private facilities	1
Elkhorn Ranch	
Number of units	35
Estimated capacity	175 people

There are 17 areas inventoried as potential recreation sites with a total of 135 acres.

Inventoried Use:

Total visitor-days	1967	63,900
Total visitor-days	1968	76,000
Total visitor-days	1969	90,600
		(50,100 spent in fishing)

(One visitor-day = 12 hours spent on the ground. Example: 2 fishermen spend 3 hours each fishing = ½ visitor-day.)

Traffic counts:

From 44,976 vehicles in 1959 to 52,783 in 1968. These figures represent a measured count from approximately May 15 through October 30 each year.

A traffic pattern study conducted at six sites between August 4 and August 13, 1968, counted the following vehicles during the 10-day period:

1.	At lower end - Fish and Game checking station	4,210
2.	Brewster Creek side road	403
3.	Ranch Creek side road	344
4.	Gun Barrel Springs on main road (1 mile above Ranch Creek)	860
5.	Tekoo Gulch on main road	440
6.	Juno Gulch on main road	442

Timber Resource

Inventoried - volumes (Lower Rock Creek Planning Unit only)

Ponderosa pine	132,114,000 bd. ft.
Larch--Douglas-fir	683,525,000 bd. ft.
Spruce-alpine fir	49,941,000 bd. ft.
Lodgepole pine	148,816,000 bd. ft.
Other	254,000 bd. ft.
Total Volume	1,014,650,000 bd. ft.
Minus Pole Timber Volume	132,124,000 bd. ft.
	882,536,000 bd. ft.
Minus volumes now in Multiple-Use Zoning (high areas, travel influence zones, etc.)	87,536,000 bd. ft.
Sawlog inventory that present allowable cut is based on	*795,000,000 bd. ft.
Tentative allowable annual cut	15 million bd. ft.

*This figure represents the timber volume on the Lolo National Forest portion of the Lower Rock Creek Planning Area. Does not include Stoney Creek.

Timber sales within the lower Rock Creek drainage on the Lolo National Forest since 1960.

	Date Sold	Volume Sold	Vol. MBF Removed	Vol. yet to be removed	Acres Cut or to be Cut
Sapphire	12-23-63	48.0*	26.7	11.3	3,331
Carron Creek	12-30-69	8.4	0.0	8.4	693
Sawmill Ridge	6-31-63	13.0*	0.3	4.0	1,432
Golden Mountain	8-3-67	11.8	8.4	3.4	1,233
Kitchen Gulch	7-30-68	6.6	3.4	3.2	605
Gilbert	8-9-58	5.5	5.5	0.0	458
			44.3	30.3	7,752
Roundwood Sale	9-16-69	16M Cords	0.0	16.0 thousand cords	

*Original contract volumes and acres adjusted with reappraisals and contract modifications.

To date the 44.3 million board feet of timber has been cut from 4,600 acres of which 2,600 acres have been clearcut and 2,000 acres have been selective cut.

Roads built in connection with the above sales:

Existing main haul roads	58 miles
Existing spur or secondary roads	200 miles

Proposed sale program for the next 5 years within lower Rock Creek area on the Lolo National Forest.

Sell 58 million board feet as follows (same as published 5-year timber sale action plan):

Name of Sale Area	Proposed F.Y. to Sell	Estimated Volume to Sell
Grizzly	1970	12 million Bd. Ft.
South Fork Gilbert	1971	3 million Bd. Ft.
Welcome Point	1973	11 million Bd. Ft.
Walquist	1973	4 million Bd. Ft.
Big Spring	1974	10 million Bd. Ft.
Wyman	1975	18 million Bd. Ft.
		58 million Bd. Ft.

Proposed road construction in conjunction with above sales:

Main haul road	42 miles
Spur or secondary roads (approximate)	100 miles

Range Resource

Approximately 20,000 acres have been inventoried as range suitable for use by domestic livestock. There are four active grazing permits in the area which permit 216 head of cattle. There are other lands suitable for livestock grazing within the area. These lands are not under permit now.

Wildlife

Approximately 20,000 acres have been estimated to be key big-game winter range or potential winter range. Of this total, approximately 18,400 acres have been inventoried as existing winter range. Surveys have indicated that range is in good to poor condition. Animal surveys have indicated that populations are down. This should have a tendency to bring range conditions up.

Although actual numbers have not been determined, deer, elk, and moose range throughout the area. Small populations of mountain lion, black bear, mountain grouse, coyote, and small fur bearers also inhabit the area. The mountain sheep population which peaked at about 200 head in 1965 now has decreased to an estimated 12 head.

Minerals Resource

Mineral deposits have not been fully determined. Exploration for gold during the latter 19th Century was universal over the area. Substantial deposits were located and removed in Welcome Creek and Basin Creek. Considerable mineral exploration is occurring in the Sliderock and Upper Ranch Creek areas. Exploration is expected to accelerate and it is probable that additional deposits will be located. The only known potential mining claims are located in the Brewster Creek and Cornish Creek drainages; these total approximately 1,000 acres.

FOREST SERVICE MANAGEMENT DIRECTION

The Forest Service proposes the following management direction for the Lower Rock Creek area:

I. BROAD DIRECTION - Recognize water as the primary resource in the entire area. Manage all other resources to protect or enhance water quality and quantity.

1. Manage the canyon area (43,500 acres) primarily for recreation (includes fishing) and aesthetics.

2. Manage the uplands areas for production of renewable resources, such as timber, forage, and wildlife.

II. SPECIFIC COORDINATING REQUIREMENTS to accomplish the broad management objectives.

WATER

1. Install a basic water monitoring system capable of measuring discharge rate and of detecting changes in temperature, turbidity, and water chemistry.

2. Protect water quality.

   a. Allow no leaching-type sewage disposal on Forest Service lands (campgrounds or special-use permits) to insure against groundwater pollution.

   b. Coordinate with State and County officials and private landowners to get proper sewage disposal facilities on private lands.

   c. Leave a "filter" or "shade strip" adjacent to all live streams. Remove only high-risk trees from these strips.

   d. Continue to abide by State water quality standards, or to the standard necessary to maintain the existing trout fishing potential, whichever is more restrictive.

   e. Revegetate all disturbed areas as soon as possible to slow surface water movement through mulching, grass seeding, and reforestation.

   f. Attempt to stabilize unstable streambanks by use of riprap, gabions, and revegetation.

3. Protect water quantity.

   Control the amount and methods of timber harvest in any one subdrainage so that peak and low streamflows are not significantly affected. Hydrological guides developed from barometer-watershed analysis data will be used to determine conservation harvest limits.

THE FISHERY

1. Maintain the stream environment and canyon area aesthetics to retain the blue ribbon classification of Rock Creek.

2. Continue efforts to provide the most favorable living conditions for the existing and future populations of game fish.

3. Coordinate with the Montana State Fish and Game Department so that recreation developments, access purchases, improvement projects, etc., are consistent with their planning for the fishery.

RECREATION

1. Manage the canyon bottom to disperse fishing pressure.

   a. Develop the west side trail system from Ranch Creek to Clark Fork River.

   b. Purchase public access rights at 1-mile intervals from Ranch Creek north to the Clark Fork.

   c. Develop small parking areas at quarter-mile intervals above Ranch Creek and where public access trails connect to the main road.

   d. Provide additional camp and picnic sites as demand and area capabilities are determined.

2. Allow no activities on Forest Service lands within the canyon area that would prohibit Recreation Rivers Classification under the National Wild and Scenic Rivers System (Section 2, Public Law 90-542).

3. Locate developments (roads, parking areas, campgrounds) away from the stream where possible.

4. Provide sanitation facilities (garbage containers, toilets) at key fishermen parking areas or points of concentration, such as Welcome footbridge, Walquist bridge, and Handley access.

5. Manage the 25,200 acres of high area for water production (quantity and quality) and for dispersed recreation.

   a. No timber harvest except for insect and disease control.

   b. Develop and sign source of drinking water for hikers especially in the Quigg Peak area.

   c. Plan and develop a good access trail system into and within the high area zone.

6. Require 100 percent disposal of slash along recreational driving routes.

7. Plan and install historical signing along the Rock Creek Road.

SOILS

1. Continue effort to get detailed soil survey of the entire area as personnel and funding permit.

2. In areas of suspect, require soil reconnaissance and/or detailed soil survey as prerequisite to all projects; i.e., roads, trails, timber sales, recreation development.

3. Require cross drainage, grass seeding, and other erosion measures on disturbed areas to insure proper dissipation of runoff to keep soil erosion to a minimum.

TIMBER

1. Timber harvest in the canyon area will be limited.

   a. All timber harvest in the canyon area must be essentially unnoticeable regardless of method used.

   b. No roads are permitted on the canyon faces.

   c. Log haul from National Forest land down the main Rock Creek road will be restricted to periods of low conflict with recreation use.

2. Reevaluate the annual cut based on the restricted harvest in the canyon area.

3. Continue intensive timber management in the upland area under sound silvicultural methods; i.e., clearcutting, shelterwood, overstory removal, individual tree selection, etc.

   a. Develop roundwood salvage in logged-over areas to intensify cleanup and utilization.

   b. Close all roads except mainline access and those secondaries needed for administration.

   c. Initiate intensive cleanup along access roads which remain open.

   d. Continue policy of removing timber "up and out" over Bitterroot Divide and out through Gillispie Creek and Schwartz Creek.

   e. Plan for reforestation of all areas within 2 years after cutting.

RANGE AND WILDLIFE

1. Continue present range allotments.

2. Establish "deferred" or rest-rotation grazing systems within existing allotments to increase vigor and production of the grasslands.

3. Do not issue new grazing permits in big-game winter range areas.

4. Reduce cattle use in favor of wildlife on winter range area where conflict arise.

5. Look for possibilities to improve and expand key winter game range through timber harvest such as thinning thick young stands at low elevation to stimulate browse production.

6. Insure adequate cover for big game within each drainage and especially adjacent to winter range areas.

7. Continue cooperation with Montana Fish and Game Department on studies of the wildlife resource.

8. Incorporate Fish and Game studies information into Forest Service resource planning.

9. Seek methods of increasing the size of the mountain sheep herd to the capacity of their range.

10. Initiate a program to close existing secondary and spur roads.

11. Develop methods to close main roads when serious conflicts with big game are identified.

TRANSPORTATION

1. Main Rock Creek Road

   There are numerous alternatives for development of the main Rock Creek Road above Ranch Creek.

   a. No development at all - current level of maintenance.

   b. Spot reconstruction of hazard areas.

   c. Reconstruction of entire road to low standard, gravel surface.

   d. Reconstruct to single lane with turnouts and gravel and dust-free surface.

   e. Reconstruct to single lane with turnouts and hard surface.

f. Reconstruct to double lane with hard surface.

The Forest Service favors alternative "d" initially with the possibility of adding the hard surface as use and maintenance indicate the need. There are no plans, surveys, or funds for this work presently available.

2. Construct no roads on the canyon face.

3. Confine secondary road access from the Rock Creek Road to the upland areas to Wahlquist and Stoney Creeks in the foreseeable future and to Ranch, Butte Cabin, and Big Hogback Creeks at some future date.

4. Provide spot dust abatement on the main canyon road as funds are available on areas where stream pollution will not be a problem.

5. Require bridging of all tributaries which are 4 feet wide or more to facilitate fish movement.

6. Require drainage structures wherever roads, permanent or temporary, cross live streams 4 feet and under in width.

7. Wherever possible do not follow stream courses with road locations. Maintain at least 75 feet buffer between all roads and streams. Favor hillside locations.

APPENDIX V

MAP OF ROCK CREEK WATERSHED

ROCK CREEK DRAINAGE

LOLO & DEERLODGE NATIONAL FORESTS

Scale

1 0 1 2 3 4 5 Miles

LEGEND

- National Forest Boundary
- Adjacent National Forest Boundary
- Drainage Boundary
- Planning Boundary
- County Line
- Reservation Line
- Wilderness or Primitive Area Boundary
- Game or Bird Refuge Boundary
- Interstate Highway
- U.S. Highway
- State Highway
- Forest Route
- Paved Road
- All Weather Road
- Dirt Road
- Primitive Road
- Trail
- Railroad
- Power Transmission Line
- Telephone or Telegraph Line
- Pipeline or Conduit
- Forest Supervisor's Headquarters
- District Ranger Station
- Forest Service Station
- Mine, Quarry or Gravel Pit
- Recreation Site, Forest Service
- Recreation Site, other than Forest Service
- Horizontal Control Station
- Permanent Lookout Station and Horizontal Control Station
- Permanent Lookout Station
- Permanent Lookout Station with Aeronautical Number on Roof
- Heliport
- Located or Landmark Object
- U.S. Mineral or Location Monument
- Gauging Station
- Sawmill
- Boundary Monument
- House, Cabin or other Building
- Schoolhouse
- Church
- National Forest Land
- Bureau of Land Management
- State of Montana
- The Anaconda Co
- Burlington Northern Railroad
- Small Private

- Primary Viewing Area – Open Woodland Type
- Primary Viewing Area – Canyon Type
- High Area
- Existing Road
- Proposed Road
- Existing Clearcut
- Existing Partial Cut
- Clearcut Under Contract
- Partial Cut Under Contract
- Wilderness Area

STA 1
STA 2A
STA 2
STA GRIZZLY
STA 3
STA 4
STA 5
STA 6
STA 6A
STA 7
STA 8
STA 9
STA 10
STA 11
STA 12
STA 13